THE QUARTERLY

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I. THE ECLIPSE OF AUGUST 7, 1869.—"ANVIL" PROTUBERANCE.

By W. S. Gilman, jun., New York.

Those who observed the solar eclipse of last August with a sizeable telescope will not soon forget the startling effect produced by the appearance of the large oval protuberance on the western limb of the moon. We were unusually favoured as to atmosphere at our station near Sioux City, Iowa, and when in addition to this it is stated that our observations were made by the aid of a 4-inch refractor—one of Mr. Alvan Clark's best—it will not seem strange that the details about to be recorded were so readily obtained.

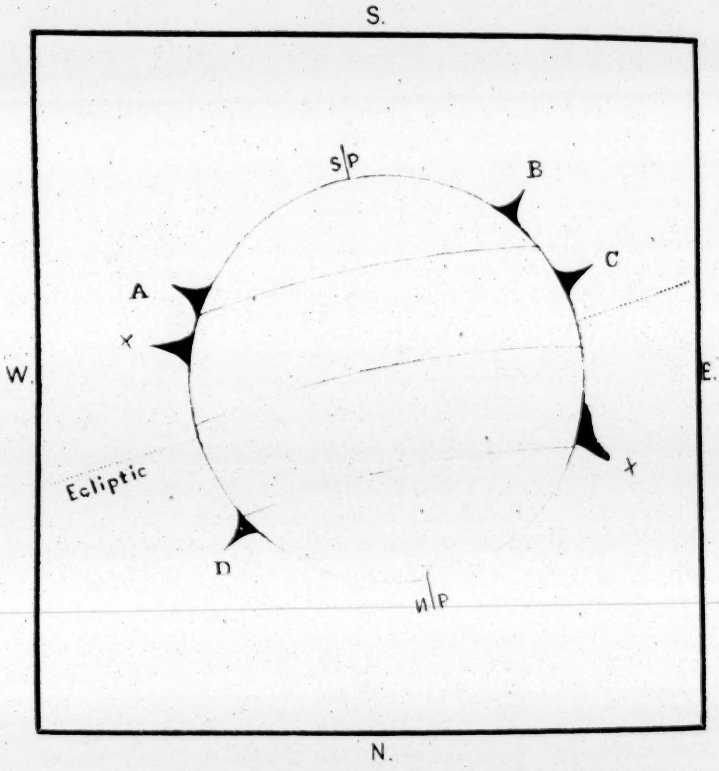
The "anvil" protuberance, for such the object is recorded in my notes, was seen by one of our party several moments prior to the totality.

Several months' study of the sun's surface had prepared me to expect the more remarkable protuberances in the southern hemisphere, and having selected the south-western quadrant as an especially favourable locality, from the presence of faculous ridges near the limb two days prior to the eclipse, the bright "anvil"-shaped mass instantly attracted my attention. Its extraordinary brilliancy enabled me afterwards to keep it in view when a considerable crescent of the reappearing sun had rendered the corona invisible.

A hasty glance at other portions of the moon's limb satisfied me that the "anvil" protuberance possessed greater interest than any other, and I therefore devoted my whole time to its consideration, except so much as was employed in obtaining several outline sketches of the corona.

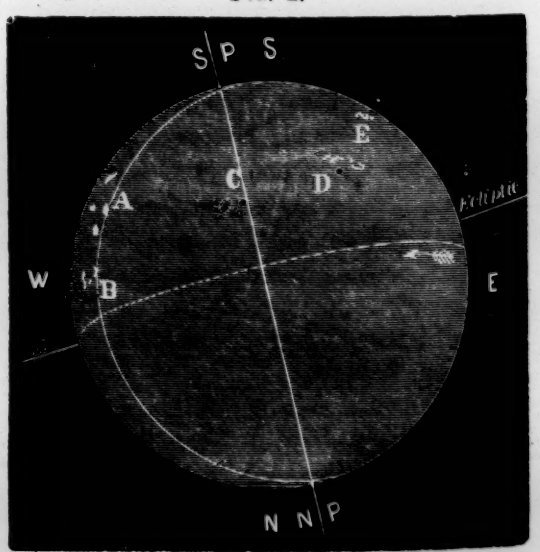
In a forecast of the probable positions of protuberances, which I made on August 5 (see Fig. 1), the double prominence at A occupies very nearly the position of the object under discussion. In Fig. 2 we have the appearance of the sun's disc on the same day, and near that part of the limb subsequently occupied by the "anvil," we notice a cluster of bright faculous spots. It was the

FIG. 1.



9. ROSE PROTUBERANCES AS FORECASTED AUGUST 5, 1869.

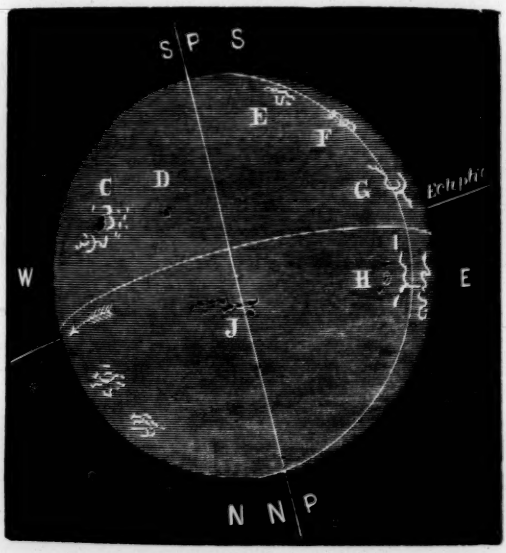
FIG. 2.



Solar disc, August 5, 1869.

intense whiteness of these objects that led me to suppose there might be hovering above the solar surface in this region gaseous exhalations that would appear during the eclipse. The white meridian in this second diagram represents the limb of the sun for the 7th of August, and it will be noticed that the cluster of faculæ is just beyond this line. A similar white meridian in the diagram giving the appearance of the sun on the 9th of August (Fig. 3), indicates the eastern limb of the sun during the eclipse.

Fig. 3.



Solar disc, August 9, 1869.

Fig. 4.

In this latter instance we have the faculous ridges marked I, G, F, E, which may be referred to prominences 4, 5, 6, and 7 of Prof. Mayer's diagram. It is worthy of special notice that the faculous masses at I are very irregularly disposed, the tortuous windings of its parts suggesting whirling motions in the photosphere. Prof. Mayer's "Eagle" prominence is a fit object to hover over such a curiously-agitated portion of the solar surface. That my sketch gives a correct representation of the windings of these ridges of faculæ I feel quite confident. While making the observation the outline was likened to a rude drawing of a camel (Fig. 4). The resemblance may appear to some if the page is inverted, the camel being supposed to face to the left.

Fig. 5 is a copy of my sketch of the spots on the sun's disc, as they appeared an hour previous to the eclipse. There was little or no change in their form or position until after the close of the phenomenon. The large spot near the eastern limb, enveloped in a platform of faculæ, is the same as that visible on the 9th (Fig. 3) near the same locality.

I was particularly impressed with the *stability* of the protuberance. It resembled a monstrous *white-hot coal*, and its outline

FIG. 5.

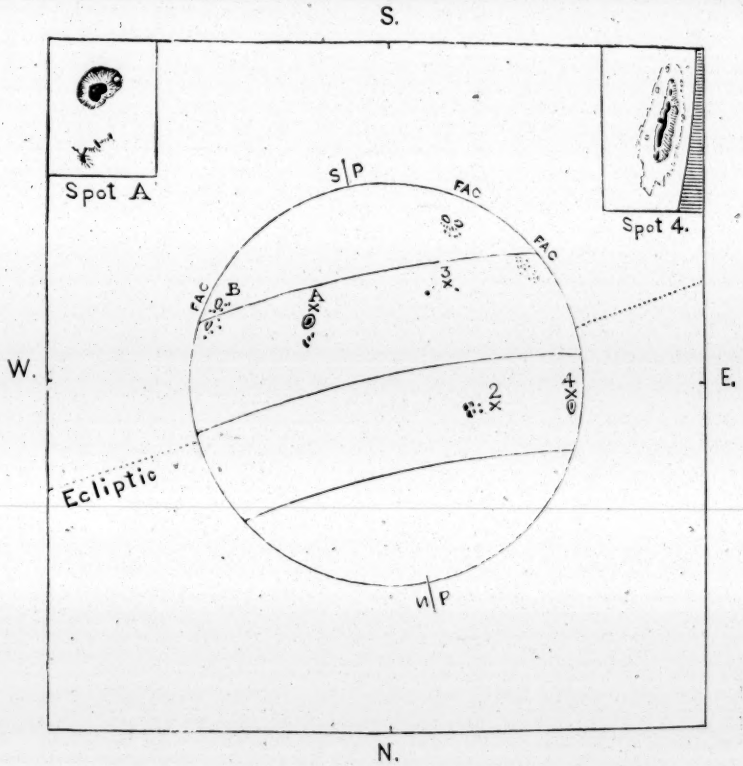
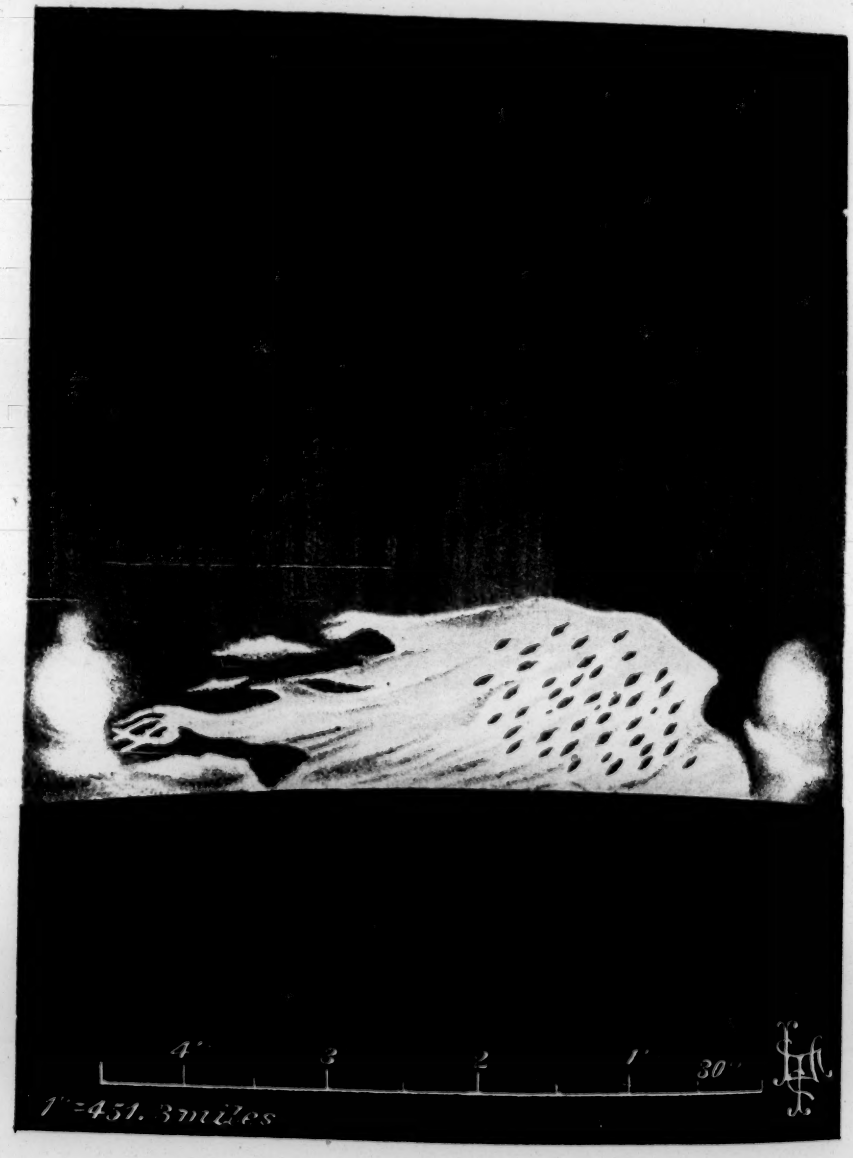


DIAGRAM SHOWING SPOTS ON THE SUN DURING THE ECLIPSE, AS SKETCHED ONE HOUR PREVIOUS TO THE FIRST CONTACT.

was sharp and well defined. The appellation "*rosy* protuberance" struck me at the time as a misnomer. I detected only bright *fire-orange* tints, like the glowing coals of an anthracite grate, with delicate crimson flakes of surprising brilliancy scattered over the southern part.

These flakes stood out against the bright background as if totally disconnected from the rest of the phenomenon. In the plate I have endeavoured to give their positions and the direction of their axes, which latter coincided with the stratification of the protuberance. I should estimate the length of these brilliant dashes of crimson light at from 3″ to 5″. Possibly in a future eclipse a momentary spectrum of them may be obtained, as their extraordinary brilliancy may make amends for their minute size.

The plate accompanying this article was prepared from my observations of the great protuberance, with the exception of the outline of the mass, which was obtained from the last Ottumwa



THE "ANVIL" PROTUBERANCE

OF THE TOTAL ECLIPSE OF AUG. 7 1869 FROM SKETCHES AND NOTES MADE DURING TOTALITY AT ST. PAUL JUNCN IOWA.

OUTLINE TAKEN FROM THE PHOTOGRAPHS

photograph of the totality. In preparing this illustration the lithographer has been very successful in copying my sketch, the plate as given recalling the protuberance to my mind with great freshness and power. The flaky structure of the protuberance I have endeavoured to indicate by a deeper tint of orange running diagonally across the flame. The southern end is more compact than that turned towards the equator, which latter breaks up into several smaller independent clouds, between which, and suspended fully 10,000 miles above the solar surface, projects the tapering point of the "anvil." A casual glance at the sketch impresses one with the idea of a down-rush of the glowing matter from the southern end to the "anvil" point.

The details of the termination of this tapering end are wholly from my notes, which record that this part of the protuberance was composed of "fibrous lines of flame" apparently in motion and emitting a tremulous light. I have now a vivid recollection of the impressions produced upon my mind by this portion of the phenomenon which riveted my attention for some moments. In the photographs the tapering end of the protuberance terminates in a misty ball, which is what we should expect if the fine lines revealed by the telescope were really in motion.

One word regarding the *corona*. By a slight movement of my instrument its limits were brought into view, and its extent quickly indicated on diagrams previously prepared. At the same time I indicated by two heavy pencil-marks the positions of certain bands, or *intervals*, in the light of the corona on opposite sides of the moon's disc. These dark intervals deserve a passing notice.

In my coloured sketch of the corona, made immediately after the eclipse, and which accompanies my report published by the Washington Naval Observatory, I have indicated the positions and character of these bands. The absorption bands of the solar spectrum occurred to me at the time as an illustration of the delicate striations in these portions of the corona. In the case of one gap a multitude of fine violet lines were compressed into a space of about 10° in width, forming, to my mind, one of the most beautiful features of the eclipse. The same striated appearance was noticed in other regions of the corona, though in a less striking degree.

These apparent gaps in the corona's light I judged to be opposite elevated portions of the chromosphere, from the fact that there was a similar diminution of light above the great protuberance, as my sketches show. This point was not carefully examined, however, from want of time. On my return from the south, in February last, it occurred to me to compare my sketch of the corona with the diagram of protuberances accompanying Professor Mayer's report in the October number of the 'Journal of the

Franklin Institute,' published in Philadelphia. This I did, for the first time, on the 9th of that month, finding a fair agreement between the southern portions of his prominences 5 and 10, and the dark bands given in my sketch. I have, therefore, little doubt but that in locating these dark intervals in my original sketches, I intended to place the western one near 285°, and the eastern one near 120°, great exactness not being obtainable in the few moments given to the observation. In speaking of these bands as *dark*, I would be understood only as meaning that they were sufficiently so to be *readily seen*.

A comparison of the Des Moines and Ottumwa pictures of the "anvil" protuberance gives the following measurements. It will be noticed that the figures are somewhat in excess of those obtained from the last totality picture made at Burlington.

	"	Miles.
Extreme length of the "anvil"	265	or 119·800
„ „ base of the "anvil"	205	„ 92·500
Greatest altitude above the sun's surface	81	„ 36·500

Thus if, as is probable, the entire protuberance was not visible, its base being beyond the sun's limb, we have a bright cloud in the solar atmosphere nearly, if not quite, equal in volume to the planet Jupiter, and which in the direction of its length would suffice to reach more than half way to the Moon in her perigee.

THE SURVEYS OF INDIA.

II. THE TRIGONOMETRICAL SURVEY.

(With a Sketch-map.)

By F. C. Danvers, A.I.C.E.

The surveys of India may be divided into two classes—*viz.* the Great Trigonometrical, and the Geological. In connection with the former, other minor operations are undertaken under the title of topographical and revenue surveys, to which we shall refer more particularly in due course.

The idea of a great trigonometrical survey of a country, to be undertaken by the Government of that country, was first conceived by General Watson, at the suppression of the rising in Scotland in 1745. The execution of it was committed to General Ray, and was originally intended to extend no farther than the disaffected districts of the Highlands. The design, however, was subsequently enlarged, and the grand trigonometrical survey of Great Britain

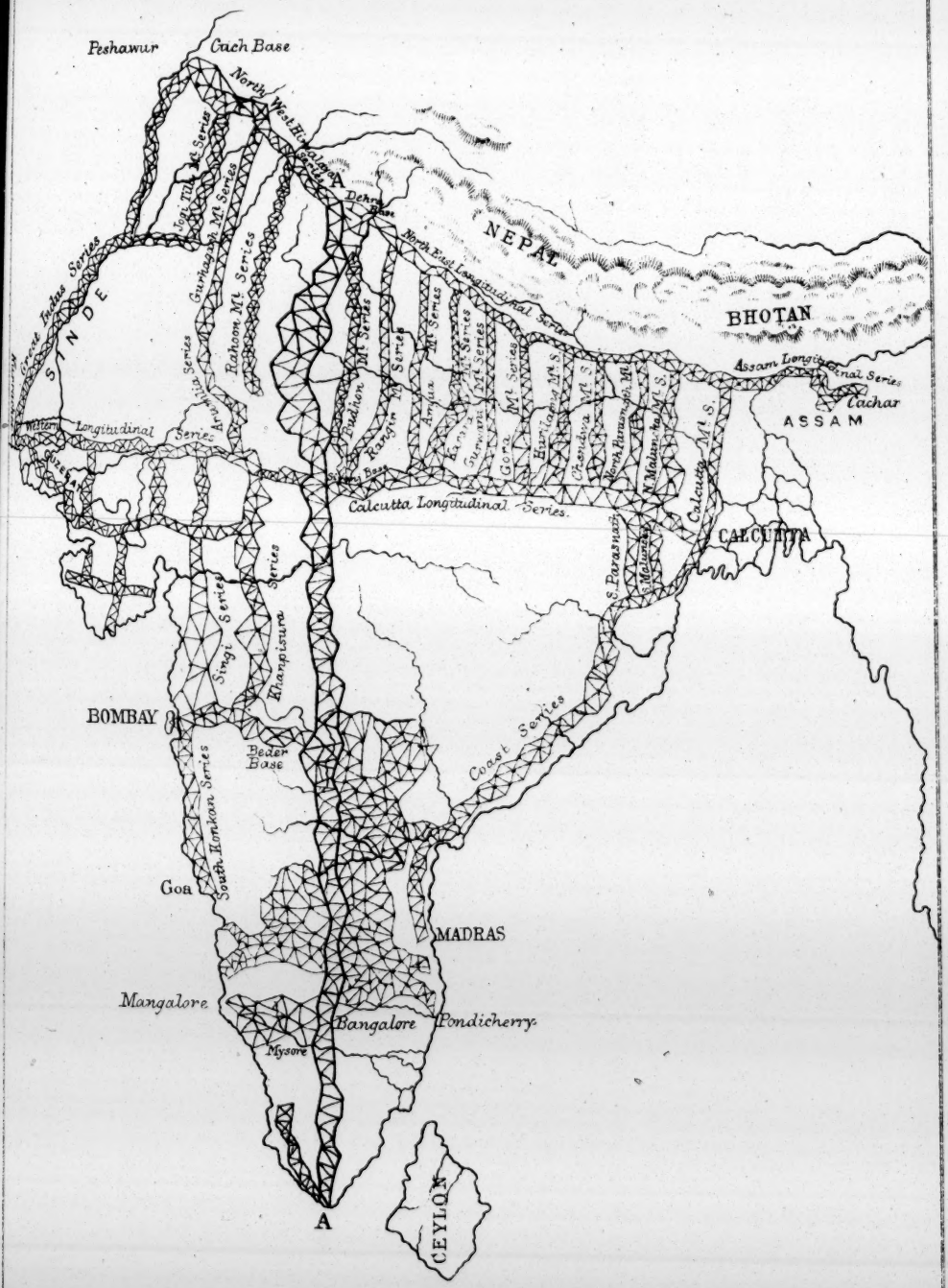
OUTLINE MAP OF INDIA

shewing the Principal Triangulation Series

of the

GREAT TRIGONOMETRICAL SURVEY.

A.A. *The Great Arc Series.*



F.C. Danvers del.

Litho Whiteman & Bass London

and Ireland was projected. Perhaps a more important survey, in some respects, than the British one was that undertaken by the French nation at the period of the Revolution. About that date the philosophers of France undertook to introduce a great reformation in regard to all those habits and usages of men which have reference to numbers, and everything—lengths, areas, moneys, weights, periods of time, arcs of circles—was to be numbered by tens, hundreds, thousands, &c. The question then came to be, What should be adopted as the basis of this standard, which was designed not only for France, but for the world? This question having been brought to the attention of the Constituent Assembly, it was proposed by M. de Talleyrand, and decreed accordingly, that the Parliament of England should be requested to concur with the National Assembly in fixing a natural unit of weights and measures; that under the auspices of the two nations, an equal number of Commissioners from the Academy of Sciences and the Royal Society of London might unite in order to determine the length of the pendulum which vibrates seconds in the latitude of 45° (as proposed originally by Huyghens), or in any other latitude that might be thought preferable, and to deduce from them an invariable standard of measures and of weights. The Commission named by the Academy had under their consideration three different units, namely, the length of the pendulum, the quadrant of the meridian, and the quadrant of the equator. The length of a quadrant of the meridian having been determined on, the measurement of an arc was entrusted to MM. Mechain and De Lambre, who began their labours in 1792, and thus commenced the trigonometrical survey of France.

The origin of the Great Trigonometrical Survey of India was not unlike that of the first Scottish Survey. After the successful termination of the war with Tippoo Saib, at the close of the last century, Captain Lambton (who had previously served as a surveyor in America, and who joined Her Majesty's 33rd Regiment at Calcutta in the year 1797) brought forward his plan of a geographical survey of part of the territory that had been conquered, and he proposed to throw a series of triangles across from Madras to the opposite coast, for the purpose of determining the breadth of the peninsula in that latitude, and of fixing the latitudes and longitudes of a great many important places, which were believed to be very erroneously determined in the survey previously executed by Colonel Mac Kenzie. Captain Lambton first submitted his plan to Colonel Wellesley, in whose regiment he had formerly served, who at once sent up the proposal to Government supported by his strong recommendation. Lord Clive was at that time Governor of Madras, and warmly approved of the undertaking, and it was accordingly sanctioned by Government.

The first base line measured by Colonel Lambton was on the table-land of Mysore, near to Bangalore. The chain used by him was one of blistered steel, constructed by Ramsden, and precisely similar in every respect to the one used by General Roy in measuring his base of verification on Rumney Marsh. It consisted of forty links of $2\frac{1}{2}$ feet each, measuring in the whole 100 feet, at a temperature of 62°, and fitted with two brass register-heads, with a scale of 6 inches to each. This chain, it appears, had originally been sent with Lord Macartney's embassy as a present to the Emperor of China, and having been refused by him, it was made over by his Lordship to the astronomer, Dr. Dinwiddie, from whom it was purchased. The measurement of this base line was commenced on the 14th October, 1800, and completed on the 10th December following. Its total length was 7·4321 miles.

Whilst these operations were being carried on, an order was on its way to England for a supply of instruments of the best manufacture that could be obtained. Amongst these was a new chain which Colonel Lambton never allowed to be taken to the field, but it was reserved as a test, whereby that actually used was constantly verified. The other instruments received from England were a 36-inch theodolite, by Cary; an 18-inch repeating theodolite by the same maker; a 5-feet zenith sector, by Ramsden; a standard brass scale, by Cary; and several small theodolites, by different makers, for minor purposes. These instruments were the finest that the state of art at the commencement of the present century could produce.

On the 10th April, 1802, the real commencement of the Great Trigonometrical Survey of India was made, although at that time the extent to which those operations would be ultimately carried was not even contemplated. Upon the resumption of operations no notice appears to have been taken of the Bangalore base line. Work was commenced by the measurement of a fresh base line of 40006·4 feet, on a plane near Saint Thomas' Mount, Madras, at no great distance from the shore, and nearly on the level of the sea. From this a series of triangles was carried, about 85 miles eastward, north as far as the parallel of 13° 19′ 49″ N., and south to Cuddalore, in latitude 11° 44′ 53″, embracing an extent of about 3700 square miles. Before describing further the progress of the survey, we must pause for a moment in order to give some account of the care taken in measuring the base line. The chain was in all respects similar to the one used at Bangalore. It was laid in coffers or long boxes, supported on stout pickets driven into the ground, and their heads dressed even by means of a telescope. At one end of the chain was a draw-post, to the head of which the near end of the chain being fastened, it could be moved a little backwards or forwards by means of a finger screw. Near the handle of the chain,

and at a point where its measuring length was supposed to commence, there was a brass scale, with divisions, which was fixed to the head of another picket, distinct both from the draw-post and from those supporting the coffers. This scale could, by means of a screw, be moved backwards and forwards on the head of the post till it coincided with the mark on the chain. A similar arrangement was made at the other end, but the handle of the chain, instead of being firmly attached to the weigh-post, as it was called, had a rope passing over a pulley; and to this rope was appended a weight of 28 lbs. to keep the chain stretched. This arrangement enabled the measurer to move his chain backwards or forwards with the greatest nicety, and when satisfied that it was correctly placed, to keep it there perfectly steady; while, by means of the registers, he marked the places of the two extremities of the chain. The chain was then lifted by twenty coolies and carried forward, the near end being adjusted to the scale which had before marked the fore end. A new chain's length was then laid off in a similar manner, and so on, until the base was finished. During these operations tents were erected over the line, and thermometers were placed in the coffers to determine the temperature of the chain; and the rate of expansion having been previously determined by experiment, the necessary corrections were made for the varying temperature of the measurement. The quantity of this correction was ·00725 inch for every degree of Fahrenheit.

Many of the triangles carried forward from this base line had sides of from 30 to 40 miles in length. In computing their length Colonel Lambton reduced the observed angles to the angles of the chords, according to the method of De Lambre; and though he computed the spherical excess, he did not use it in any other way than as a measure of the accuracy of his observations. The chords, which were the sides of the triangles, were then converted into arches; and as Colonel Lambton had contrived that the sides of the four triangles which connected the stations at the south and north extremities should lie very nearly in the direction of the meridian, their sum, with very little reduction, gave the length of the intercepted arch, which was thus found to be 95721·326 fathoms. By a series of observations for the latitude, at the extremities of this arch, made with a zenith sector, the amplitude of the arch was found to be 1°·53233, by which, dividing the length of the arch just mentioned, Colonel Lambton obtained 60494 fathoms for the degree of the meridian bisected by the parallel of 12° 32′. This, till the survey was extended farther to the south, was the degree nearest to the equator—excepting that in Peru, almost under it—which had yet been measured. The next object was to measure a degree perpendicular to the meridian, in the same latitude. This degree was accordingly derived from a distance of more than 55

miles, between the stations at Carangooly and Carnatighur, nearly due east and west of one another. Very accurate measures of the angles which that line made with the meridian at its extremities, were here required; and these were obtained by observations of the Polar star when at its greatest distance from the meridian. For this purpose a lamp was lighted, or blue lights were fired at a given station, the azimuth of which was found by the Polar star observations, and afterwards its bearing was taken in respect of the line in question. Thus the angle which the meridian of Carangooly makes at the pole with that of Carnatighur, or the difference of longitude of these two places, was computed. It was then easy to calculate the amplitude of the arch between them; and thence the degree perpendicular to the meridian at Carangooly was found to be 61061 fathoms. Upon comparing this degree of the perpendicular with the degree of the meridian, the compression at the poles would appear to be equal to $\frac{1}{210}$. A writer in the 'Philosophical Transactions' for 1812, p. 342, contended that, on account of an error in calculation which escaped Colonel Lambton, the foregoing measurement should be diminished by 200 fathoms, thus reducing the length of the degree of the perpendicular to 60861 fathoms, which would give $\frac{1}{330}$ for the compression. These measurements were made in 1803.

In May, 1804, a base of verification of 39793·7 feet (7·536 miles, reduced to mean sea-level) was measured by Lieutenant Warren, Colonel Lambton's assistant, near Bangalore; and though the distance was nearly 160 miles, the computed and measured lengths of this base differed only 3·7 inches, or about half an inch in the mile; a proof of the great care and accuracy with which the work was conducted. This base was adopted for the origin of the great Indian arc series, to which we shall presently refer more particularly. From it a series of triangles was carried across the peninsula to the Malabar coast, which they intersected at Mangalore on the north and Tellicherry on the south. The heights of the stations were all determined from the distances and observed angles of elevation. The most considerable heights were at Soobramanee and Taddiandamole, in the western ghauts, not very far from the coast, the former being 5583 feet, and the latter 5682 feet above the level of the sea; but notwithstanding having to cross such elevations, after carrying the survey over a distance of 360 miles, it was found that the sum of all the ascents, and of all the descents, reckoned from the level of the sea, differed from one another only by $8\frac{1}{2}$ feet. From the triangles thus carried across the peninsula, a correct measurement of its breadth was obtained, and one considerably different from what was before supposed. The distance from Madras to the opposite coast, in the same parallel, was ascertained to be very nearly 360 miles; whereas, until then,

the best maps made it exceed 400 miles. All the principal places on the old maps, which had been fixed astronomically, were also found considerably out of position: for example, Arcot was out 10 miles, and Hydrabad no less than 11 minutes in latitude and 32 minutes in longitude.

For a long period the operations referred to above were frequently interrupted by the disturbed political condition of the country, which was often the scene of warlike operations; for it was not until the Marquis of Hastings destroyed the Pindaree confederacies in 1818 that the peninsula and Deccan settled down into quiet and repose. The mysterious character of the instruments and operations, as well as the planting of flags and signals, always more or less awakened the apprehensions or excited the jealousy of the native princes; and it required, therefore, no ordinary tact, firmness, and patience, in order to conciliate their good-will.

Between the years 1802 and 1815, a network of triangles was, under the superintendence of Colonel Lambton, carried over the whole country as high as 18° latitude, whereby the peninsula was completed from Goa on the west to Masulipatam on the east, with all the interior country from Cape Comorin to the southern boundaries of the Nizam's and Mahratta territories. Subsequent to this achievement, the great arc triangulation was extended nearly to Takal Khera, in latitude 21° 6′. The greater part of the Nizam's eastern territories were triangulated by meridional series between the Kistnah and Godavery, and considerable progress was made in the longitudinal series from the Beder base towards Bombay. The area comprised by the whole of the operations prosecuted during the time Colonel Lambton was superintendent aggregated 165,342 square miles. In October, 1817, the Marquis of Hastings, impressed with the important utility of the trigonometrical survey, resolved to transfer the control over its operations to the Supreme Government of India, which took effect from the 1st January, 1818, and Colonel (then Captain) Everest was appointed assistant to the superintendent, whom he subsequently succeeded upon the death of Colonel Lambton on the 20th January, 1823. Colonel Everest first acted as chief assistant during the latter part of 1818, and he was employed, in the first instance, in the triangulation of the eastern parts of the Nizam's dominions, and subsequently on a longitudinal series of the great triangles emanating from the Beder base line towards Bombay. He was engaged on this important work at the time of Colonel Lambton's death, by which event he succeeded to the office of superintendent, and immediately proceeded to concentrate the resources at his disposal on the extension of the great arc series, which, after many difficulties, was at length carried up to latitude 24°, where a base line was measured at Seronj.

After this, Colonel Everest proceeded to England, returning

thence, in 1830, provided with geodetical instruments and apparatus of every description executed by the most skilful artists of the day, including a complete base-line apparatus, the invention of Colonel Colby, precisely similar to that employed on the Ordnance Survey; a great theodolite, 36 inches in diameter; two 18-inch theodolites; and a variety of smaller instruments from 12 inches diameter downwards. The signals, all of the most efficient kind, and recently invented, consisted of heliotropes, reverberatory lamps, and Drummond's lights, of which the two former have been exclusively used.

In addition to the duties of Superintendent of the Trigonometrical Survey, Colonel Everest had, on his return to India, to perform those of Surveyor-General of India. In 1833 the offices of Deputy Surveyor-General at Madras and Bombay were abolished, and their duties devolved upon the Surveyor-General, so that Colonel Everest had now to perform the work which had hitherto occupied the undivided attention of four officers.

By the end of 1832 a longitudinal series of triangles had been completed from Seronj to Calcutta, where another base line was measured. Upon the completion of that work the measurement of the great arc was re-commenced, after a cessation of seven years. It was carried on from that time unremittingly till December, 1841, when the whole Indian arc from Cape Comorin to the Himalayas, forming the main axis of Indian geography, was finally completed. The area comprised by the great arc operations, principal and secondary, aggregated 56,997 square miles, including the revision of the section from Beder to Kalianpoor, and the measurement of three base lines, each from $7\frac{1}{2}$ to 8 miles in length, *viz.* those of Beder, in latitude 18°; Seronj, near Kalianpoor station, in latitude 24°; and the Dehra base, about 70 miles north of Kaliana station, in latitude 29° 30′, where the great arc actually terminates; this distance being observed on account of the proximity of the Himalayas. On comparing the actual measurement of the Debra Dhoon base by Colley's apparatus with that calculated from the Seronj base, measured by the chain in 1824, a difference of nearly $3\frac{1}{2}$ feet was found. In former times this would have been considered a very satisfactory agreement, seeing that the length of the base is $7\frac{1}{2}$ miles, and its distance from the new base upwards of 400 miles in a straight line; but Colonel Everest considered the difference as indicating a much larger error than ought to exist, regard being had to the precision of the new methods. In order to set the question at rest, he resolved to re-measure the old base with the more complete apparatus he now had at his command. This operation was completed in January, 1838, when it appeared that the length given by the chain measurement of 1824 was too short by nearly 3 feet, as compared with the new result.

In the year 1829 a trigonometrical survey in the Bombay Presidency was commenced by Lieutenant Shortrede, on an independent base and point of departure. This survey proceeded in an unsystematic manner until it was brought under Colonel Everest's control in 1831, when, finding that no use could be made of this confused net of triangulation, the Colonel directed that the longitudinal series should be taken up where he left off in 1823. This was concluded in 1841, the series extending over a distance 315 miles in length.

The space at our disposal will not admit of a detailed account of the several series of triangulation carried out by the Trigonometrical Survey Department; they will, however, be seen by reference to the accompanying map. Besides the great arc series, extending from Cape Comorin to Dehra Dhoon, there are two longitudinal series, the one extending from Cachar, in Assam, to Peshawur, and the other from Calcutta to Kurrachee: between these are numerous series of triangles, those to the east of the great arc being at distances of about one degree, or 60 miles apart, taking meridional directions, thus forming what is called a gridiron system, similar to that adopted in the French and Russian surveys. Base lines are measured at the extremities of the longitudinal chains, and at the points where the chains cross Colonel Everest's arc; thus the triangulation is divisible into large quadrilateral figures, with a base line at each corner.

Colonel Everest was succeeded in the appointment of Superintendent of the Great Trigonometrical Survey and Surveyor-General of India by Captain (afterwards Sir) Andrew Waugh, in December, 1843, who held the combined offices for seventeen years. Sir Andrew Waugh left the service in 1861, when he was succeeded by Colonel J. T. Walker, R.E., as Superintendent of the Great Trigonometrical Survey, and by Colonel Thuillier, R.A., as Surveyor-General of India, both which officers respectively fill those appointments at the present time.

The charts of the trigonometrical operations are zincographed on a scale of 4 miles to the inch, and the geodetical co-ordinates for each station with azimuths and linear distances are entered upon them, so that each chart forms a brief but complete record of the survey results. Skeleton charts of levels, on a scale of 2 miles to the inch, are also prepared and photozincographed; these show the combined results of both trigonometrical and spirit levelling reduced to the common datum of the mean sea-level of Kurrachee harbour.

Revenue Survey.—The Revenue Survey Branch, in the Bengal Presidency, first commenced in the year 1822. It comprises a scientific periphery admeasurement of the land by means of angular and linear measurements, performed with theodolites and steel chains;

and its operations extend into such parts of the country as are under British administration and yield a fair revenue. It is a definition and survey of village boundaries and estates, and may also be termed a large scale topographical survey, as it affords accurate topography of every district falling within the scope of its operations. The system followed is that of traversing with the theodolite and steel chains, known as Gale's method of land-surveying, modified to secure greater accuracy and efficient checks on both the boundary and interior detail measurements. Large areas are first traversed with the better class of small theodolites having from 12 to 8 inch horizontal circles, starting from an initial station, where the azimuth is observed, to obtain the true bearings of stations in advance, the distances between stations being measured with steel chains twice over and repeated in rough ground, or wherever any doubts arise. These traversed areas, called main circuits, being in the first instance traversed and proved, afford a complete check on the minor or block circuits into which they are subdivided; and these minor circuits, being in their turn traversed and proved true on the basis of the main circuit containing them, reduce the errors in the village boundary work to a minimum. The trifling angular and linear discrepancies which may occur in the village traverse circuits are adjusted *inter se.*

The interior or detail survey, which is filled in by plane-table or compass and chain, rests on these small village polygons, plots of which are furnished to the native plane-tablers. The stations of the main circuits are permanently marked, and the masonry platforms which mark the tri-junctions of villages are, whenever practicable, made theodolite stations. The boundaries of villages are measured by offsets taken to all boundary pillars from the lines enclosing the village polygons, these linear and offset measurements being carefully recorded in the village boundary field-book.

Along the Revenue Survey lines of levels, all masonry platforms marking the junction of three villages which fall on or near the line are invariably adopted as permanent bench-marks. These being all marked prominently on the maps of the Revenue Survey, the entry of the data will be readily and easily made, showing the height of each bench-mark above the mean sea-level, as determined by starting from and closing all the lines of Revenue Survey levels on the Great Trigonometrical stations, or the bench-marks of the principal series of levels of the Great Trigonometrical Survey of India.

In connection with the Revenue Survey, levelling operations were carried on, during 1868–69, in Oudh and Rohilcund, and they have subsequently been extended to the central provinces, Bhamulpoor and Bengal. The object of these is to run series of levels across districts not yet contoured, and to combine the results of the

levelling operations of the Revenue Survey with those already completed, or about to be prosecuted, by the Irrigation Branch of the Public Works Department.

The field mapping is all executed on a scale of 4 inches to the mile.

In addition to the regular professional revenue survey of villages, there has always been a minute measurement of fields for assessment purposes, conducted by native agency, entirely under the collector or settlement officers. These are crude operations after native fashion.

In the presidencies of Madras and Bombay, minute cadastral measurements of fields are in progress under European officers; these surveys are essentially for settlement and revenue purposes, and have no connection with the Indian Survey Department, nor are they under the direction of the Surveyor-General of India.

Topographical Survey.—The Topographical Branch of the Indian Survey Department is under the immediate superintendence of the Surveyor-General of India, and had its origin in the Revenue Survey. Its operations are confined chiefly to hilly and jungle-covered ground, yielding but little revenue, in parts of the country not actually under British management, and in friendly native states along the British frontier; and its object is to obtain a cheap, rapid, and reliable first survey for geographical and administrative purposes. The groundwork or basis of its operations is secondary and minor triangulation dependent on the Great Trigonometrical Survey operations, from which all the initial elements of latitude, longitude, elevation, distance, and azimuth are derived. The triangulation is carried on in a network covering the ground with points or stations at about 3 to 4 miles apart. The instruments employed for the secondary triangulation are vernier theodolites with 12 and 14 inch azimuthal circles; the horizontal observations are taken on four zeros repeated and the vertical angles on two zeros. For the subsidiary or minor network of triangles, theodolites with 7 and 8 inch azimuth circles are used, and the angular measurements are made with two zeros repeated.

The detail work, or delineation of the configuration of the ground, is executed usually on the scale of 1 inch to the mile by means of the plane-table. Some topographical surveys in cultivated or valuable tracts are on a scale of 2 inches to the mile; and a few others, in very broken and wild ground, on a scale of 2 miles to the inch. In addition to the 1-inch survey, the Topographical Branch undertakes the plans of all the important cities, forts, and strongholds in native states; these are mapped on scales varying from 6 to 16 inches to the mile.

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III. THE GEOLOGICAL SURVEY OF INDIA.

(With a Sketch-map.)

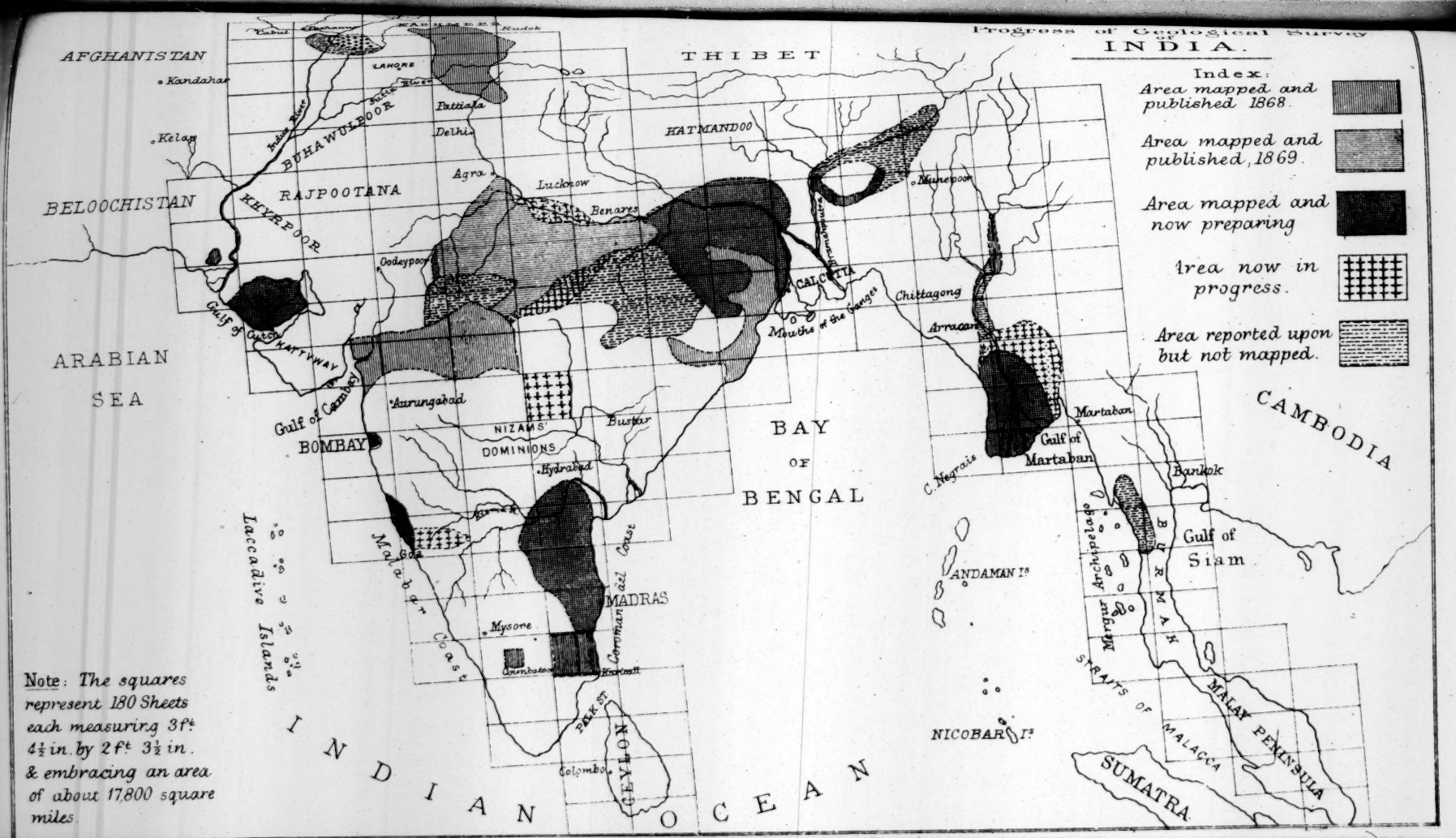
By H. WOODWARD, F.G.S.

SIXTEEN years have now elapsed since the Geological Survey of India commenced its systematic labours, and it may now be interesting to give some account of the progress that has been made, and to note a few of the results to which the Government officers have been led.

Some time beforehand, in 1851, Mr. (now Dr.) T. Oldham, the Superintendent of the Survey, arrived in Calcutta.

The work which he was then required to do was to go from place to place, and, without loss of time, to search for coal and other minerals of economic value; to furnish reports, and thus to indicate by observations in a few places the important results that might be obtained from a detailed survey of the whole of the country. Great were the difficulties with which he had to contend at the outset, and for a long time afterwards; so that not until 1856 was he able to establish that regular system of operations carried on by a staff of officers, small at first, and even in 1863 numbering but fifteen geologists.

No one was better fitted for the task in hand than Dr. Oldham; he had been Local Director of the Geological Survey of Ireland, and was previously Professor of Geology in Trinity College, Dublin.



Note: The squares represent 180 Sheets each measuring 3 ft. 4½ in. by 2 ft. 3½ in. & embracing an area of about 17,800 square miles.

With his small band of Geologists, the Survey was carried on with vigour, and periodical reports were published, accompanied by maps, geologically coloured, and sections of the country described.

The value of the establishment was soon appreciated by the public, and numerous applications for reports on geological matters were made, as well as for aid in analyses of coal, minerals and ores, of soils, water, and in assays. Such information and assistance was given to many private individuals, as well as to Government departments and to companies.

The earlier observations were, as might be expected, fraught with much difficulty. But few and isolated notices, compared with the size of the country, had been written upon it. The labours of Dr. Carter, of Bombay, of the Revs. Hislop and Hunter, Presbyterian missionaries in Tinnevelly, and some others, had certainly done a little towards paving the way for a classification of the rocks; and Mr. Greenough had, in 1854, after many years' labour in compilation, prepared a map of India, upon which he had depicted all that was then known concerning the geology of the country.

Dr. Oldham,* however, found it necessary to establish several new groups to receive (provisionally) the various rocks that were met with, inasmuch as for many—and these some of the most widely-extended and important groups of rocks—there was no definite horizon from which to work either up or down. Over thousands and tens of thousands of square miles not a fossil was found, save some vegetable remains, affording, at the best, but very imperfect evidence. The richly fossiliferous rocks of the Himalaya and Sub-Himalaya being widely separated from all the rocks of the Peninsula by the broad expanse of the Alluvium which unites the valleys of the Ganges and Indus, it was impossible to trace out, by their aid, any superposition.

To endeavour to remedy this, it was found advisable to examine many distinct tracts, and to make more or less rapid observations on distant parts, which, although interfering with the continuous progress of the Survey, were generally of essential service in leading to definite results on important geological points, which, in the ordinary progress of the work, could not have been arrived at for many years to come.

The climate of India necessarily restricts the work to certain portions of the year. The working season lasts about seven months, and differs very materially in the southern part of the Peninsula from that in Bengal. In the latter district, the close of the Indian financial year (the 31st March) nearly coincides with the close of the field season. In Madras the season is then not half over.

* See Mr. Horner's Anniversary Address to the Geological Society of London. 1861.

Considering the great exposure to which all field-geologists working in the open country are unavoidably subjected, and the necessity for their visiting, and often remaining in, the most malarious and unhealthy parts, it is not surprising to learn that the whole staff are seldom at work at one time. The illness of one or more, and the necessity for leave of absence, is generally recorded in the Annual Reports. But it is grievous to learn the loss by death of five or six officers since the Survey has been in operation, whilst several have been forced to resign from ill-health.

These causes have occasioned much loss of time. It is seldom possible, Dr. Oldham remarks, to meet with persons qualified to supply the vacancies immediately. There is, moreover, absolute necessity for a considerable amount of training, occupying generally a year, before any newly-appointed Assistant can become really useful, and able to carry on alone the mapping of a district.

The pecuniary temptations furnished to individuals to join the Survey are not very great, the *maximum ratio* of pay being 500 and 600 rupees per month, but this is only obtainable after eight or ten years' service. The salary, as on the British Survey, is very fair to commence with, but equally discouraging in prospect.

The latest report of Dr. Oldham, dated the 3rd January, 1870, is accompanied as usual by an index-map, showing the area surveyed, and published to the end of 1869, and that in progress. A reduced copy of this map accompanies our notice.

The Atlas of India, which includes Burmah and the Malay Peninsula, comprises about 180 sheets, portions of about 64 of which have been mapped, while others have been visited and reported upon.

A very large area has not yet been surveyed topographically, so that the direction of the detailed mapping by the Geological Survey has some restrictions. The size of the sheets is 3 feet $4\frac{1}{2}$ inches by 2 feet $3\frac{1}{2}$ inches, and each contains an area of about 17,824 square miles.

The principal part of the work has been carried on in Central India. The faultiness of the existing maps of the country was found a serious drawback to successful progress, but so far as possible they were corrected, and every effort was made to render them of the utmost service. It was soon found, however, that the character of the geological work must be suited to the available maps of the district, and with very imperfect maps to attempt great detail would be useless. For all practical purposes, the boundaries of the geological formations could generally be fixed with sufficient accuracy.

But few sheets have been entirely surveyed. This, however, would be accounted for by the necessity, previously stated, of examining many different and distant parts for the purpose of arriving

at a classification or knowledge of the order of superposition of the rocks in India; and when the vast area embraced by each sheet is taken into consideration, it is not surprising that few have been completed.

A glance at the map best shows the amount of field-work that has been done, and considering the many difficulties and dangers that have had to be encountered—not forgetting the disturbed state of the country during the Indian mutiny in 1857—we must congratulate the Survey on the great progress it has made.

Besides the preparation and publication of the geological maps, the Survey now maintains three periodicals of letter-press.

The first part of the 'Memoirs' appeared in 1856, and since then six volumes have been completed, containing thirty-two geological reports (over 2200 pp. of letter-press), and the first part of vol. vii. has recently been published. All are well illustrated with maps and sections.

Particular attention has been given to the coal-bearing deposits. The 'Memoirs' contain reports on the Coal-fields of Talchir, Ranigunj, Jherria, Bokaro, Ramgurh, &c.

The coal-fields of Bokaro and Ramgurh belong to the ordinary, or Damuda series.

In the Jherria coal-field, the two series, Talchir and Damuda, are developed.

The lower, or Talchir, contains no coal.

The Damuda series contains many seams, very irregular, and varying in thickness from a few inches to 20 feet and more. Numerous coal-seams are much injured by trap-dykes, which have ramified through them, and which have rendered the coal useless. There is also a general tendency to ignition in all the seams, owing, it is thought, to the presence of iron pyrites, which gives rise to spontaneous combustion. Metamorphism is produced in the shales in proximity, giving to them the character of well-burnt bricks.

Dr. Oldham calculates that there is an available quantity of coal in this Jherria field of about 465,000,000 cubic yards, or, roughly, tons of coal.

In Sinde there is a lignitic coal of Lower Tertiary age, but not worth working. In one of his earlier reports Dr. Oldham noticed the existence of Tertiary coal by the river Irrawaddy, near Prome.

Coal of excellent quality has been found in Assam, which lies near the river Brahmapootra, convenient for transport by water.

Considerable doubt attached to the age of the coal-fields of Damuda, Talchir, and Nagpur. The reported discovery in them of certain plants was thought to place them in the Triassic or Oolitic period. But it has since been ascertained that these remains occur in shales above and distinct from the Coal-measures.

Comparisons have been made of late between the several series

of sandstones, &c., associated with the coal in Bengal and those of Central India. The vast extension and great constancy in mineral character of the Talchir rocks (which form the base of the great coal-bearing series) have been fully established, and the thinning out of the beds in passing to the west has received further support. The entire Coal-formation, which in the east gives five well-marked subdivisions (in ascending order, Talchir, Barakar, Ironstone shales, Ranigunj, and Panchet), becomes, at a short distance to the west, only a threefold series, comprising the Talchir, Barakar, and Panchet subdivisions. Additional proofs have been brought forward to show that on the large scale, the present limits of these Coal-measures coincide approximately with the original limits of deposition, and are not the result of faulting, or even mainly of denudation.

And Dr. Oldham expresses his opinion that the great drainage basins of India were on the large scale marked out, and existed (as drainage-basins) at the enormously distant period which marked the commencement of the deposition of the great plant-bearing series. In this point of view, local variations in the lithological type, local variations in the thickness of the groups, and even their occurrence or non-occurrence, are only necessary consequences of the mode and limit of formation.

In 1861 Dr. Oldham gave a summary statement of the amount of coal raised throughout India for the past three years, which was about 850,000 tons. The total amount of coal raised in India generally was, in 1858, about 226,140 tons; in 1859, about 347,227 tons; and in 1860, about 370,206 tons. Of this quantity the Ranigunj field yielded by far the greater part. The only mode of transport, however, from this field was by the river Damuda, a stream only navigable during the freshes of the rainy season, after which it becomes so dry that no more coal can be sent to market until the next season.

In 1867 Dr. Oldham made a report on the Coal-resources of India.* The extensive fields which occur are not distributed generally over the country, but are almost entirely concentrated in one, a double, band of coal-yielding deposits, which with considerable interruptions extends more than half across India, from near Calcutta towards Bombay.

Little more than surface workings are carried on—the deepest pits scarcely exceed 75 yards, while certainly one-half of the Indian coal which has been used up to the present date has been produced from open workings or quarries.

Dr. Oldham concludes that out of the whole series of Indian coals, the very best of them only reach the average of English coals, and that on the whole they are very inferior to them. It should, however, be borne in mind that until all the fields are carefully

* Being a return called for by the Right Hon. the Secretary of State for India.

mapped, any estimates of the Coal-resources and production of British India must be defective.

Besides the coal-reports, the 'Memoirs' contain papers on the gold-bearing and other economic deposits, also many describing the geology generally and physical geography of particular areas. Some few treat of palæontology.

One very important paper describes the Vindhyan series, as exhibited in the North-Western and Central Provinces of India. The district described included the greater part of Bundelkund. The Vindhyan series is divided into an upper and a lower division, the former gives rise to great table-lands, the latter furnishes more diversified scenery. The area affords many striking instances of the power and effects of subaërial denudation on a grand scale. As yet the Vindhyan rocks have yielded no fossils; they appear to be older than the Talchir, and may possibly turn out to belong to a period about the age of the Devonian. Lithologically they consist of alternations of limestones, shales, sandstones, and conglomerates, often distinguished by local names, as for instance the "Bijigurh shales." Some of the beds furnish good building stone.

In order to gain a more rapid publication of many isolated facts noticed during the progress of the Geological Survey, and which were scarcely adapted to the 'Memoirs,' a new publication called the 'Records' was started in 1868. The series contains notices of the current work of the Survey, lists of contributions to the Museum and Library, &c., and it is intended also to publish analyses of such books published elsewhere as bear upon Indian geology, and generally to notice all facts which come to light illustrative of the geology of Hindostan. The third volume is now in course of publication.

Among the numerous published Reports the following appear most worthy of special notice.

The Surat Collectorate, in the Bombay Presidency, although a comparatively flat country, possesses many features of geological interest. Traps, ranging from basalt to a soft shaly-looking amygdaloid, are met with, and resting unconformably upon these is the great Nummulitic series. This consists of sandstones, conglomerates, and limestones, with nummulites, molluscs, fossil-wood, and fragments of bone. Alluvium covers a large extent of the district, and the cotton (or black) soil covers it over many large tracts of the country. This soil seems to be the residuum left by the decomposition of an alluvium largely composed of volcanic (trappean) *débris*. It usually occurs in districts in which trap-rocks abound, as for example in the Poorna valley, West Berar.

The Poorna alluvium is of considerable depth, in places about 150 feet. Much of it produces efflorescences of salts, chiefly of soda; and in many places the wells sunk in it are brackish or salt.

Comparisons have recently been drawn between the Alluvial deposits of the Irrawadi and the Ganges. Every river that discharges its waters into the sea has the character of its deposits influenced according to whether the area be in a state of subsidence, quiescence, or of elevation. Generally in every large river-basin two distinct alluvial deposits will be met with. The older of these may be either marine (estuarine) or fluviatile (lacustrine), or of a mixed and alternating character; but the newer group is essentially fluvio-lacustrine, and directly produced by the existing river. While no very great thickness of the newer stratum can anywhere have been deposited without a corresponding subsidence of the area, a very large accumulation of the older or estuarine deposit may have taken place during an elevation of the area covered by it.

The Ganges and Irrawadi present examples of rivers subjected, respectively, to the former and latter conditions. The alluvium of the Ganges, as ascertained from a well-boring at Fort William, consists of 70 feet of the newer or fluviatile deposit, resting on the denuded surface of the "kunker clay." This clay is regarded as an estuarine deposit accumulated during an upward movement of the land. The Gangetic area is now considered to be undergoing depression at a rate adequately counterbalanced by the accession of sediment brought down by the river. The alluvium of the Irrawadi belongs almost entirely to the older group, this river-delta being at the present time in precisely the same condition as was the delta of the Ganges when the first layers of its alluvium, 70 feet below the present surface at Calcutta, were being deposited. The difference in the fertility of the two areas is attributed to the greater richness of the newer alluvium, and hence the inability of the delta of the Irrawadi to compare with that of the Ganges in agricultural produce.

The geology of the neighbourhood of Madras is noticed in the third volume of the 'Records.' The greater part of this district is occupied by rocks of Secondary, Tertiary, and Recent ages, the remainder is taken up by metamorphic rocks, forming part of the great gneissic series of Southern India. Some time previously, beds of magnetic iron-ore were pointed out in the metamorphic gneiss rocks of the Madras Presidency, the supply of which was considered to be practically inexhaustible.

The Rajmahal plant-beds consist of conglomerates, sandstones, gritty clays, and shales.

The Laterite deposits are also pointed out. They comprise clayey conglomerates, gravels, and sands, which graduate one into the other. The gravels contain pebbles of quartzite and gneiss, mixed with pisiform ferruginous pellets. Other deposits called the Conjeveram gravels are noticed; they differ from the laterite beds in the absence of ferruginous matter. Both appear to contain imple-

ments of human manufacture in the shape of axes and spear-heads made of chipped quartzite pebbles, and of the same types as those which occur in the gravels of Western Europe. They were spread rather widely over a large extent of area in the country to the west and north of the city of Madras, and have been made of the best substitute which this portion of the country could afford for flint, namely, the very hard and semi-vitreous quartzites of the Cuddapah series.

In gravel, situated near Pyton on the banks of the Godavery, an agate-flake has been found, which is undoubtedly an artificial form. It is figured in vol. i. of the 'Records.'

We have but briefly and imperfectly noticed a few of the more important results arrived at by the energetic labours, *in the field*, of Dr. Oldham and the officers of the Geological Survey. This work—superintended by Dr. Oldham—has been carried out by the many able assistants who have served under him, among whom we may mention H. B. and J. G. Medlicott, H. J. and W. F. Blanford, C. Æ. Oldham,* W. Theobald, jun., F. R. Mallet, A. B. Wynne, R. B. Foote, T. W. H. Hughes, W. King, jun., F. Fedden, &c.

We will now turn our attention to the palæontological work.

A Museum of Economic Geology was established at Calcutta in 1840, and in 1856 it was placed in connection with and under the same superintendence as the Geological Survey of India. There are also Museums at Madras, Bombay, and Kurrachee.

During the progress of the Survey numerous fossils have been collected, and specimens are being constantly added to the Museum. Indeed Dr. Oldham reports that they increase so rapidly that no room can be found for their proper exhibition, and in the examination and description of them it is impossible to keep pace. During the year 1869 more than 20,000 specimens passed through the hands of the curator and his assistant. A suitable building is, we are informed, now in course of erection at Calcutta, where the fine collections already brought together will be properly arranged and exhibited.

One of the more richly fossiliferous tracts is at Spiti and Rushpu in the Himalayas, where representatives of Silurian, Carboniferous, Triassic (Lilang series), Rhætic (Para limestone), Lower and Middle Lias, and three subdivisions of the Jurassic period, and also Cretaceous rocks are believed to occur.

In order to figure and describe the species of organic remains collected by the Survey, the 'Palæontologia Indica' was instituted. This quarto publication is issued in fasciculi, each containing about six plates, and published once every three months. Five series of these fasciculi have been published.

* This able geologist died 30th March, 1869, aged 37 years. See Obituary, 'Geol. Mag.,' vol. vi., p. 240.

The *first series* was printed in 1861, and treated of the Fossil *Cephalopoda* of the Cretaceous rocks of South India, containing the *Belemnitidæ* and *Nautilidæ*, by H. F. Blanford; the *Ammonitidæ*, by Dr. F. Stoliczka, formed matter for the *third series*.

The Cephalopoda were found to include 146 species, of which nearly one hundred were *Ammonites*, three only *Belemnites*, whilst of Nautilus there were 22 species, &c. Thirty-seven of these species were found identical with species known in Europe and other countries. Ninety-six quarto plates are devoted to the illustration of these fossils.

The Gasteropoda of the Cretaceous rocks form the subject of the *fifth series;* they are illustrated with sixteen plates, and are described by Dr. Ferdinand Stoliczka.

Two hundred and thirty-seven species of Gasteropoda are described. Among them, four species of *Helicidæ* are deserving of special attention from the rarity of land-shells in these Cretaceous rocks, and particularly as they are said to belong to types still found living in the same or neighbouring districts.

Dr. Stoliczka considers that the South Indian Cretaceous deposits only represent the Upper Cretaceous strata, beginning with the Cenomanien. The larger number of representative species were found to agree with the Turonien. The original notion of representatives of Neocomian beds existing in South India loses support from the more complete examination and comparison of the species.

The *second series* of the 'Palæontologia Indica' is devoted to the Fossil Flora of the Rajmahal series (Jurassic), six fasciculi of which have been published. The descriptions are by Dr. Oldham and Professor Morris. The Rajmahal beds occur near Madras, in Bengal, and Kutch. At Madras the beds contain no carbonaceous matter, which in their equivalents in other parts of India occurs so largely as to form coal-seams. The plant-remains occur chiefly in a white shale. They include *Palæozamia*, *Dictyopteris*, *Tæniopteris*, *Pterophyllum*, *Pecopteris*, *Stangerites*, *Poacites*, &c.

The *fourth series* on the Vertebrate Fossils of the Panchet rocks is by Professor Huxley, and is illustrated with six plates. These remains consist of numerous fragmentary and sometimes rolled bones, the majority being vertebræ, with a few teeth, portions of crania, &c. They were discovered in a stratum of conglomerate sandstone exposed by the Damuda river near Deoli, fifteen miles west of Ranigunj, and they are of great interest as being the first remains of vertebrata discovered in the great group of rocks associated with the coal-bearing formations of Bengal. They proved to belong to a peculiar group of fossil reptiles (*Dicynodontia*) hitherto only known from South Africa. The strong analogy which these South African rocks offer to some of the Indian rocks had been insisted on by Dr. Oldham, before this discovery, on the strength of

the plant-remains alone, and this has been strangely confirmed by the discovery of reptiles of the same type (*Dicynodontia*).

Very many years must necessarily pass away before the Geological Survey of India is completed, nor can Dr. Oldham and his present staff hope to see its accomplishment, but they have done sufficient already to indicate the great geological features of the country, and we may hope to see in one of their future publications, a table of succession of the Indian strata as far as at present determined, with their probable European equivalents.

IV. RAINFALL IN ENGLAND.

By W. Pengelly, F.R.S.

As regularly as the new year comes, and very speedily afterwards, come Mr. Symons's 'British Rainfalls,' containing the well-tabulated results obtained by many hundreds of rain observers whose gauges are spread over Great Britain and Ireland, as well as the adjacent isles.

The data contained in these annual publications are of great interest, not only in themselves and as they stand, but because they are capable of being worked up and discussed in various ways, some of which I will now proceed to illustrate.

The Rainfall of England and Wales.—During 1869, there were in Great Britain south of the Tweed and Solway no fewer than 1093 gauges at work, giving an average of about 21 for each county, but, as may be supposed, without any approach to uniformity of distribution. They were most thickly strewn in Middlesex, and most sparingly in Montgomeryshire, there being one gauge for every 5973 acres in the former, and for every 284,060 acres in the latter; that is relatively about forty-seven times as many gauges in the one as in the other. On the average, there was in the entire kingdom one gauge on every 34,149 acres; hence, were the distribution uniform, each gauge in England and Wales might be supposed to occupy the centre of a square measuring 7·3 miles in the side.

It is eminently creditable to the zeal and perseverance of their meteorologists that the mountainous and thinly-populated counties of Carnarvon, Cumberland, and Westmoreland, were amongst those in which the relative number of gauges exceeded the average for the entire country; thus for every ten gauges in England and Wales as a whole, there were 10·5 in Carnarvonshire, 18·4 in Cumberland, and 25·5 in Westmoreland. In the last, moreover, there were no fewer than twelve gauges on ground upwards of 1000 feet above the sea, three upwards of 2000 feet, and one at the height of

3200 feet. Westmoreland had five gauges more than 1000 feet high; and though Carnarvon had none exceeding 850 feet in height, the returns from every gauge in the county were in every respect complete, as they contained full information as to height above the sea and the ground, the total annual rainfall, the number of wet days, and therefore of the average wet-day rate of rain.

The stations varied in height from the sea-level, at Hull, to 3200 feet above it, at Scafell Pike in Cumberland. The least county average height was 53 feet, in Cambridgeshire; the greatest was 715 feet, in Radnorshire; whilst that for the entire kingdom was 297 feet. This general average was surpassed in twenty-five counties, but not reached in the remaining twenty-seven.

The tops of the gauges were by no means at one uniform height above the ground on which they stood. In several cases they were level with the surface, whilst one at Cockermouth was 100 feet above it. Taking the counties as separate wholes, the least average height was 13 inches in Leicestershire, and the greatest 8 feet 7 inches in Cambridgeshire; while the mean height for the entire country was 2 feet 9 inches. This general average was exceeded in twenty-four counties, but not reached in twenty-six.

During the four years ending with December 31st, 1869, the least annual rainfall at any station was 7·84 inches—the receipts in 1869 of a gauge at Sheerness, the top of which was 70 feet above the ground and 79 feet above the sea; whilst the greatest was 207·49 inches, received in the same year, in a gauge 6 inches above the ground, and 1077 feet above the sea, at the Stye in Cumberland. During the four-year period just named the average annual rainfall in the different counties as separate wholes varied from 68·91 inches in Cumberland to 22·55 inches in Bedfordshire; the average for the entire kingdom being 35·37 inches. The three numbers were as 195 : 63 : 100. The general average was exceeded in eighteen counties but not reached in thirty-four; the former, or "wet" counties, being to the latter, or "dry" ones, as 1 : 2 nearly.

According to the Registrar-General, England and Wales contain 37,324,915 statute acres; hence, with an average rainfall of 35·37 inches, they every year receive 4,792,261,544,086 cubic feet of rain; that is, a quantity sufficient to fill a canal having an uniform breadth and depth equal to those of the Thames at low water at London Bridge (700 × 12·5 feet), and a length of 103,721 miles, or more than four times the circumference of the earth. Taking the weight of a cubic foot of water at 1000 oz. av., England and Wales annually receive 133,712,677,011 tons of rain. Were the entire rainfall of the year converted into a hailstorm it would be a globe having a diameter of 4730 feet = ·9 miles.

The eighteen "wet" counties are, in descending order, Cumber-

land, Merionethshire, Westmoreland, Montgomeryshire, Carnarvonshire, Cardiganshire, Cornwall, Pembrokeshire, Monmouthshire, Glamorganshire, Caermarthenshire, Lancashire, Devonshire, Brecknockshire, Radnorshire, Anglesea, Derbyshire, and Somersetshire—those, in short, which, with the exception of Cheshire, Denbighshire, and Flintshire, form our western coast from the Solway to the Land's End, including the Bristol Channel to the eastern margins of Monmouth and Somerset shires, together with the inland mountain counties of Montgomery, Brecknock, Radnor, and Derby. Obviously our rains come from the west and south-west; high lands have a greater rainfall than those which are low; and, as a corollary, districts having loftier lands between them and the Atlantic must receive less rain than those not thus sheltered,—a truth well illustrated by the comparative dryness of Cheshire, Denbigh, and Flint shires, which lie on the dry side of Carnarvonshire, Anglesea, and Ireland.

In the provisional language of meteorologists, those days are termed "wet" on which not less than ·01 inch of rain falls in the twenty-four hours. During the four years already mentioned, the greatest number of wet days recorded in one year at any station was 315 in 1866, at Patterdale Hall, in Westmoreland; and the least number was 77 days at Beeston Lock, Nottinghamshire, in 1868. The greatest county annual average for the same period was 207 days in Merionethshire, the least 137 days in Bedfordshire, whilst for the entire kingdom it was 169 days: the three numbers being as 122 : 81 : 100.

In twenty-two counties the general average number was exceeded, whilst it was not reached in twenty-eight; the former group included all the counties of excessive rainfall, with the exception of those of Brecknock and Pembroke.

From what has been stated above, it appears that the county of greatest average rainfall was not that of the greatest average number of wet days, and that the difference between the rainfall extremes was greater than that between those of the number of wet days, it being 132 per cent. in the former, but no more than 41 per cent. in the latter case. In other words, though a great annual rainfall, and a great number of wet days may be said to go together, the former, instead of depending entirely on the latter, depends also on the average wet-day rate of rain.

Cumberland, as we have seen, received, on the average, 68·91 inches of rain on 192 days per year; hence its average wet-day rate of rainfall was ·36 inch (= 68·91 ÷ 192), and this was the maximum. The minimum was that of Cambridgeshire, amounting to no more than ·15 inch; whilst the average for England and Wales, as a whole, was ·22 inch; the three numbers varying as 164 : 68 : 100.

Fourteen counties, all of them having excessive rainfalls, exceeded the general average wet-day rate.

It may be convenient here to recapitulate in a tabular form the principal facts just established in connection with the three pluvial elements of England and Wales, and which show that the rainfall of a district depends on the wet-day rate of rain rather than on the number of wet days.

	Max.	Min.	Mean.
Average annual *relative* rainfall	195	63	100
Average annual *relative* number of wet days	122	81	100
Average *relative* wet-day rate of rain	164	68	100

On taking the "wet" and "dry" counties as two distinct wholes, their pluvial elements stand as below:—

	Actual.		Relative.	
	Wet.	Dry.	Wet.	Dry.
Annual average rainfall	49·14 in.	28·68 in.	171	100
Annual average number of wet days ..	185 days	160 days	116	100
Annual average wet-day rate of rain ..	·27 in.	·18 in.	150	100

The Influence of Height above the Ground on the Rainfall.—It has long been known that at the same station a gauge on or near the ground receives more rain than one higher above it. Dr. Dalton stated, in 1802, that the ratio of the quantity of rain collected on the top of St. John's steeple, Manchester, to that collected on the ground in the vicinity, about 50 yards below, was in summer as 2:3 nearly, and in winter as 1:2 nearly.*

Mr. Symons's 'British Rainfall' extends over the ten years beginning with 1860; and at several of the stations whence he receives returns there are two or more gauges at different heights above the ground. Omitting all whose vertical distances are less than 10 feet, and taking the highest and lowest only at the same station, there were in Great Britain and Ireland 226 cases spread over the ten years which are available for the discussion of the question immediately under notice.

The "vertical gauge-distances" varied from 10 feet to 99·5 feet, and averaged 40·5 feet. The total amount of rain received by all the lower gauges was 6812·02 inches, and by the upper ones 5707·98 inches; showing an actual defect of 1104·04 inches, or a relative defect of 16·3 per cent. This, divided equally between the 226 cases, gives a total deficit of 4·885 inches each per year. Dividing, again, by the average gauge-distance, or difference of height

* 'Monthly Magazine,' vol. xiv., p. 5. 1802.

(40·5 feet), the result is an annual average deficit of ·12 inch, or ·4 per cent., for every foot of elevation above the ground. In other words, if the rainfall, received during a year by a gauge on, or a few inches above, the ground, be divided into 1000 equal parts, for every foot a second gauge is placed vertically above this, it will, *on the average*, receive four such parts fewer.

It is obvious that this *uniform* average "foot-defect" of ·4 per cent. of the receipts of the lower gauge presupposes that the lower gauges are all at the same small height above the ground, and that for a given depth or zone of atmosphere the actual deficit is the same, whether the zone be at a high or low level. The first is unfortunately anything but true, as some of the lower gauges are level with the surface, whilst others are as much as 8·5 feet above it.

Waiving this however, interesting information on the second point is contained in the returns, tabulated below, from Southampton, Oxford, and Preston, and which have been selected from the entire list simply because they extend over a greater number of years than any of the others, and because the difference in the heights of the gauges, that is, the depth of the zone of atmosphere on which the experiments were made, was not the same at any two of the stations.

Stations.	Vertical gauge-distances.	Relative Foot-defects.										
		1860.	1861.	1862.	1863.	1864.	1865.	1866.	1867.	1868.	1869.	Means.
	ft. in.											
Southampton	18 1	1·03	·92	1·19	·97	1·03	1·33	1·04	·55	·66	·63	·93
Oxford . .	22 9	·64	·59	·65	·78	·81	·69	·86	·30	..	·28	·60
Preston . .	49 5	·23	·27	·32	·31	·25	·27	·34	·34	·42	·26	·30

An inspection of the Table shows that whilst at each station there were fluctuations from year to year, the foot-defect was invariably an inverse function of the vertical gauge-distance. In other words, if a series of gauges be placed vertically above one another, at uniform distances, the first or lowest will receive, on the average, more rain than the second, which in its turn will receive more than the third, and so on; but the difference between the receipts of the first and second will be greater than that between those of the second and third, and so on.

The foregoing Table contains twenty-nine annual returns from the three stations collectively. If with them we include all the annual returns from stations having gauges differing in height from 10 to 70 feet, and form them into six groups, such that the first shall be made up of those only having a gauge-distance of from 10 to 20 feet, the former alone inclusive; the second, of those whose distance ranged from 20 to 30 feet; and so on to the sixth or last; we get the following Table, in which the Southampton returns just

given, obviously belong to the first group, those from Oxford to the second, and those from Preston to the fourth:—

Vertical gauge-distances. in feet.	Number of Annual Returns.	Average Foot-defect, per cent.
From 10 to 20	22	·939
„ 20 to 30	53	·512
„ 30 to 40	50	·395
„ 40 to 50	35	·378
„ 50 to 60	19	·305
„ 60 to 70	13	·374

From the foregoing figures, it appears that if the contents of the lower gauge be divided into 100,000 equal parts, the upper gauge will, on the average, receive 939 fewer such parts for every foot of elevation, provided such elevation be not less than 10 nor more than 20 feet; or 512 fewer such parts per foot provided the vertical gauge-distance be not less than 10 nor more than 30 feet, and so on.

A glance at the last or right-hand column shows: 1st, that, with one exception, the foot-defect diminishes with increased vertical gauge-distance; 2nd, that the difference between two consecutive foot-defects becomes less and less with increase of difference of elevation, and almost disappears at the height of 70 feet.

At certain stations, as Cardington and Cockermouth, there are three gauges, each at a different height above the ground, whose receipts are tabulated below:—

Stations.	Height of Gauges.	Actual Rainfall in inches.						Mean Relative Rainfall.	Mean Foot-defect, per cent.
		1865.	1866.	1867.	1868.	1869.	Means.		
	ft. in.								
Cardington	0 0	27·25	26·88	23·57	21·94	21·25	24·18	100	..
„	3 6	26·18	25·53	22·26	21·30	20·33	23·12	96	1·14
„	36 0	22·23	21·37	17·26	16·94	17·44	19·05	79	·58
Cockermouth	0 6	..	50·77	38·35	50·12	46·31	46·39	100	..
„	6 6	..	48·19	36·29	48·02	44·48	44·24	95	·83
„	100 0	..	31·30	20·07	27·10	22·86	25·33	55	·45

Here, as before, the receipts of the gauges, at the same stations, were greater when nearest the ground.

The difference of receipts increased with increased difference of elevation.

The deficit, per cent. per foot, became less as the difference of height became greater.

And on comparing the results from the two stations, it appears

that whilst a difference of 3·5 feet in vertical gauge-distance gave a foot-defect of 1·14 per cent. at Cardington, a distance of 6 feet gave a foot-defect of only ·83 per cent. at Cockermouth; and that whilst a vertical gauge-distance of 36 feet at the former gave a foot-defect of ·58 per cent., a distance of 99·5 feet at the latter gave a foot-defect of no more than ·45 per cent.

Enough has probably now been said to show, what indeed has long been known to meteorologists, the importance of the height of the gauge above the surface on which it stands, with the consequent absolute necessity of this height being everywhere the same if we are to attach any meaning to the "Rainfall of District," or if rainfall statistics are to be of any scientific value.

Devonshire, for example, is one of the "wet" counties of South Britain, and, from its situation, Plymouth might have been expected to have been one of the "wet" stations of the county. This expectation is quite in harmony with the popular belief, which finds expression in such remarks as "It always rains at Plymouth." "Don't forget to take your umbrella when you go to Plymouth," and so on. Nevertheless, the published returns do not confirm it. The average annual rainfall of the county during the four years ending with December 31st, 1869, was 42·40 inches, whilst at Plymouth it was no more than 39·45 inches, that is a deficit of 7 per cent. If the figures are to be trusted then, Plymouth is for Devonshire a "dry" station, at least so far as the annual rainfall is concerned, whatever it may be with regard to the number of wet days, about which no returns are made. The case is rendered by no means less remarkable when we turn to the other stations in the neighbourhood, all of which confess that they are "wet." Thus Ham, Saltram, and Ridgeway are all within 4 miles of it—the first in a north-westerly, and the second and third in a north-easterly direction—all farther from the sea, and all have their gauges on less elevated ground; all, in short, have conditions likely to betoken a less rainfall, yet their average annual falls, during the four years so frequently spoken of, have exceeded the county mean by 4, 9, and 16 per cent. respectively. The solution of the problem, however, is not far to seek; it lies in the fact that whilst all the other stations have their gauges very near the ground, the Plymouth gauge is 35 feet above it.

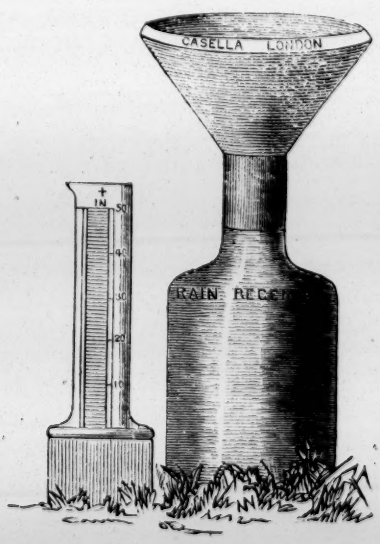
Two other Devonshire stations, Tavistock and Mount Tavy, tell the same story. They are barely a mile apart, and very nearly at the same height above the sea, but the average rainfall of the latter exceeds that of the former by upwards of 12 per cent.—a fact for which no other explanation can or need be given than the sufficient one that the Mount Tavy gauge is only one foot, whilst that at Tavistock is 20 feet, above the ground.

In this age, so famous for the application of science to commercial

purposes, it surely ought to be possible to turn to account the defective receipts of rain gauges high above the surface; and in the absence of a better, perhaps the following suggestion may be of service:—Watering-places and other towns of fashionable and wealthy resort, are always naturally desirous of advertising their attractions. Knowing that their visitors dislike rain, their business is clearly to prove that they are remarkably exempt from it. It is true that a wet day is comfortless and a bore simply because it *is* wet, not because the rain is or is not heavy; hence all that is necessary is to place the town gauge high above the ground, make no record of the number of wet days, publish the annual rainfall thus ascertained, and with it those of towns which have no temptation to this form of utilization. The rainfall will undoubtedly stand in very favourable contrast with that of any of the other towns, and the general public will readily conclude that the wet days were correspondingly few.

Seriously, however, our method of collecting rainfall data is anything but satisfactory, and the figures must fail in the rigid accuracy which science requires.

In concluding this part of my paper, I venture to express the hope that at no distant day all observers will employ gauges of the same size and construction, which shall be tested before being located; that they shall all be at one uniform small height above the surface; that the ground on which they are placed shall be at least approximately level, and quite unoccupied for some distance from them; that none of them shall be placed on buildings, since these, especially when large, cannot but be thermal agents and affect the rainfall; that, with the exception of a few very elevated stations, the number of wet days shall be duly recorded; and that, for ascertaining the exact relation of rainfall to height above the surface, a series of such gauges shall, at least, at one station in each county, be placed practically in the same vertical line at uniform successive distances, say of 10 feet.



Without intending to express any doubt respecting the accuracy of other gauges, it may be stated that probably none are to be preferred to the "five-inch gauge" made by Mr. Casella, under the auspices of the British Association, and which, through the kindness of the maker, is figured above. It consists of a Receiver, a Reservoir, and a Metre. The last, of course, requires no descrip-

tion; and the reservoir may be dismissed with the remark that it is a bottle of stone or glass, 9·7 inches high. The Receiver is a copper circular funnel, 5 inches in diameter, 4·8 inches deep, and terminating in a tube 8·5 inches long and ·3 inch in internal diameter. Outside this, and soldered to the bottom of the funnel, is a cylindrical phlange, 2·25 inches deep, and having between it and the tube a space for the reception of the head of the reservoir, which it exactly fits, so that when united a horizontal section through the phlange would disclose three tightly-fitting concentric tubes. The phlange keeps the receiver steady, prevents the rain which falls on the outside of the funnel from leaking into the bottle, and reduces to a minimum the evaporation of the contents of the reservoir. When fitted together the height of the instrument is 14·1 inches; but when in use it is placed firmly in the ground, and should have its top 9 inches above the surface.

Supposed Influence of the Moon on the Rainfall.—That the moon is very influential in, or at least closely connected with, all changes of the weather, is a belief at once widely spread and deeply rooted. Our satellite can neither be full, nor new, nor "fill her horns," without, as is popularly believed, causing or indicating some alteration in the state of the weather. If she is caught "lying on her back," or, in other words, if, when she is less than a semicircle, her cusps are pointed upwards so that the straight line joining them is more or less approximately parallel to the horizontal plane, the fact is supposed to be an indication if not the cause of rain. If she submits to be "towed by one star and chased by another," that is, if she is between and near two conspicuous stars, so that the three bodies are at least nearly in a straight line, the fishermen expect a storm.

Though meteorologists show no favour to these and many similar beliefs, some of them admit that it is neither unphilosophical nor contrary to fact to regard the moon as a meteorological agent. Thus, Sir John Herschel, from his own observations, regards it as a meteorological fact that the clouds have a tendency to disappear under the full moon, and adds that a slight preponderance in respect of quantity of rain near the new moon over that which falls near the full, would be a natural and necessary consequence of a preponderance of a cloudless sky about the full.* M. Arago, who concurs in this opinion, states that the expression "the moon *eats the clouds*," is common in France among country people, and especially among sailors.† The latter philosopher adds that the results obtained from meteorological observations in Germany and in Paris, were that the maximum number of rainy days occurred between the first quarter and full moon, and the minimum between the last

* 'Outlines of Astronomy,' par. 432, and note, p. 285. 5th edit. 1858.

† 'Popular Astronomy,' Smyth's Translation, vol. ii., ch. xxiii., pp. 311–313. 1858.

quarter and new moon; the ratios being 100 : 121·4 in Germany, and 100 : 126 in Paris; but that in the south of France the minimum number of rainy days occurred between the full moon and the last quarter. He concludes with the remark that "the question requires to be examined afresh."*

Having by me an unbroken series of carefully-made rainfall observations from the beginning of 1864 to the present time, I have tabulated the results below so as to show the amount of rain, the number of wet days, and the wet-day rate of rain in each of the four quarters of the seventy-four complete lunations, beginning with the new moon on January 9th, 1864, and ending with January 1st, 1870—a period of 2185 days.

The word "quarter," as used here, may be defined thus:—*The first quarter begins with the day of the new moon, and ends with the day immediately preceding that on which, according to the almanac, the moon reaches the first quarter, and so on for the others.*

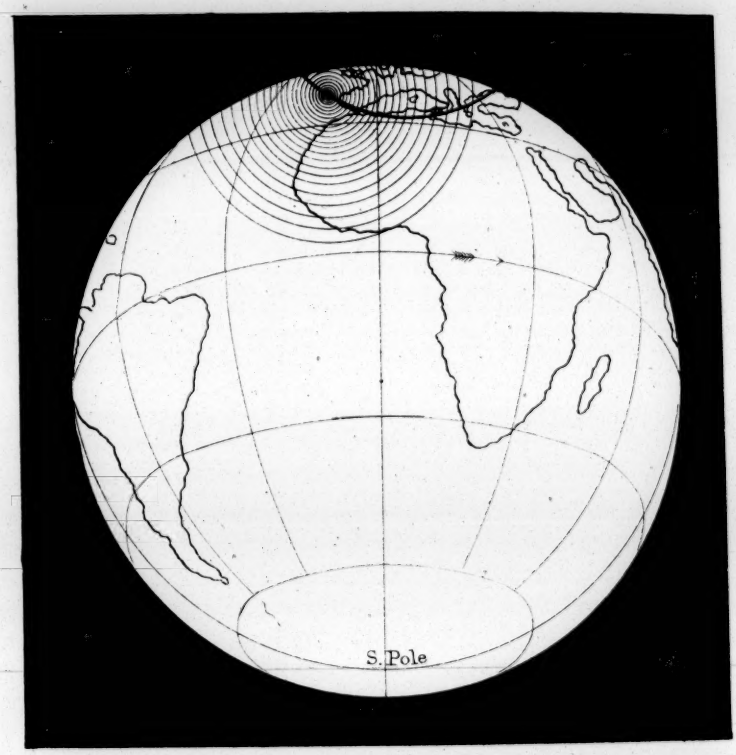
	Quarters.				Totals.
	First.	Second.	Third.	Fourth.	
Actual rainfall in inches	56·66	58·87	57·30	55·90	228·73
Relative rainfall	2477	2547	2505	2444	10000
Number of times rainfall was more than 25 per cent.	33	30†	34	30	..
Number of times rainfall was less than 25 per cent.	41	43†	40	44	..
Number of dry days	274	301	241	266	1082
Number of wet days	274	248	307	274	1103
Relative number of dry days	253	278	223	246	1000
Relative number of wet days	248	225	278	248	1000
Mean wet-day rate of rain in inches	·2141	·2374	·1866	·2043	·2073
Relative mean wet-day rate of rain	103	115	90	98	100

From the foregoing Table, it is obvious that with regard to the three pluvial elements, in South Devon, during the six years ending with January 1st, 1870, the four quarters of the seventy-four moons may be arranged, in descending order, as below:

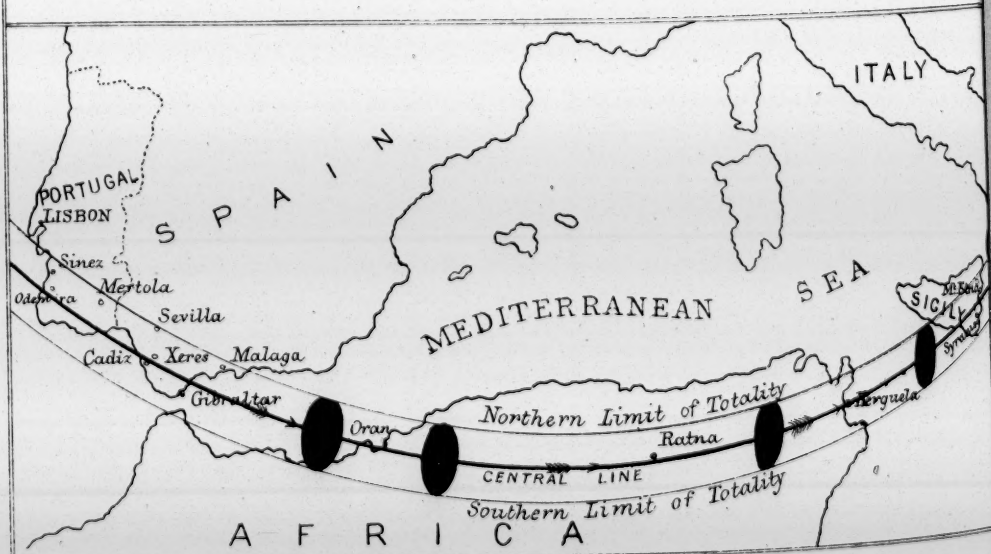
Rainfall.	Number of Wet Days.	Wet-day Rate of Rain.
Second. (greatest)	Third. (greatest)	Second. (greatest)
Third.	Second.	First.
First.	Fourth.	Fourth.
Fourth. (least)	First. (least)	Third. (least)

* 'Popular Astronomy,' Smyth's Translation, vol. ii., ch. xxxv., pp. 317, 318.

† The rainfall of one "second quarter" was exactly 25 per cent. of that of the lunation.



How the Earth is presented towards the Sun during the Eclipse, and the path of the Moon's Shadow.



The course and shape of the Moon's Umbra.

Litho Whiteman & Bass, London

This tabular summary shows:—

1st. That the quarters arrange themselves in an entirely different order under the different heads, with the single exception of the second being the quarter of greatest average rainfall and also of greatest average wet-day rate of rain.

2nd. That the least average rainfall was in the quarter immediately preceding the new moon, instead of being, as Sir J. Herschel supposes, about the full moon.

3rd. That the maximum number of wet days was in the third quarter, and the minimum in the first; thus differing in every particular from the results stated by M. Arago to have been obtained in Germany and Paris, on the one hand, and in the south of France on the other, which, as we have seen, differed from one another.

This discussion may be appropriately closed, perhaps, by echoing Arago's remark, that "the question requires to be examined afresh."

V. THE APPROACHING TOTAL SOLAR ECLIPSE.

By R. A Proctor, F.R.A.S., &c.

The eclipse of next December is less remarkable in many important respects than the two total solar eclipses now commonly known as the Indian and American eclipses of 1868 and 1869. The former of these was distinguished among all the eclipses of recent times by the exceptional extent to which the lunar disc overlapped, during central totality, the concealed disc of the sun. For more than six minutes at some stations no direct solar light was visible. The eclipse of last year was not distinguished in this particular way, though the duration of totality—at some stations exceeding four minutes—was far from inconsiderable. What rendered the American eclipse so extremely important, even more important than the Indian one, was the fact that a large proportion of the track of the moon's shadow lay across a region dotted over with well-armed observatories. It is probable that on no previous occasion has so large an array of practised observers been employed in scrutinizing the phenomena of a total eclipse; and it is absolutely certain that so many appliances had never before been employed to render the researches of the observers effective.

In both respects the approaching eclipse is less important. The greatest duration of total obscuration will be but 2 m. 11 s.; and the track of the moon's shadow only skirts the region within which the principal European observatories are situated. In fact, the only parts of Europe traversed by the shadow are the southern provinces of Spain and Portugal, Sicily, the southern extremity of Italy, and

parts of Greece and Turkey. And of these regions only those in the Spanish peninsula and Sicily are practically available, because in the others the duration of totality will be less and the sun will have but a small elevation. In Greece, for instance, and Turkey, though the phenomena of totality may chance to be well seen, yet the chance is not such as would justify an expedition from the principal astronomical centres of Europe. The best places of all for observing the eclipse will undoubtedly be those along or near the track of totality in Algeria. These, however, will probably be left to the astronomers of France.

Fig. 1 shows the actual presentation of the earth towards the sun, and the course and shape of the moon's shadow on December 22nd next. The hour is supposed to be solar noon at Greenwich. The earth must be conceived to be rotating in the direction shown by the arrow (on the equator), and at such a rate that any meridian line in the figure will reach the place occupied by the next meridian towards the right in two hours. The black spot to the west of Spain represents the shadow of the moon at the hour named. This shadow is surrounded by the penumbra, a portion of which, however, remains throughout the eclipse beyond the northern limits of the earth's disc. The course of the shadow is indicated by the curved line taken through the black spot. If an observer on the sun could trace the apparant path of the moon's centre across the earth's *disc*, he would not find it curved in this way, but appreciably straight. As the earth is rotating, however, the disc turned towards the sun undergoes an appreciable change during the duration of central eclipse, and the motion of the different points of the earth along parallels curved like those shown in the figure, causes the path of the moon's centre with reference to the earth's *globe* (distinguished here from her disc as seen from the sun) to have the shape indicated in the figure.

Central eclipse begins on the earth generally at twenty-six minutes before noon,—in other words the black shadow shown in the figure as already well advanced is supposed to have entered on the disc twenty-six minutes before the epoch corresponding to the figure. Central eclipse concludes for the earth generally at twenty-one minutes past one, or eighty-one minutes after the epoch corresponding to the figure. The total interval during which the moon's shadow (as distinguished from her penumbra) falls upon the earth is thus 1 h. 47 m.; and the amount of motion due (during this interval) to the earth's rotation can be conceived by remembering that the southern extremity of Spain moves during totality from a place below the dark spot in the figure (and on the proper parallel, of course) to about the place occupied in the figure by Sicily.

It will be evident from a further consideration of the relations

presented in Fig. 1, that there are two respects in which this eclipse is unfavourable. First of all, the track of the shadow lies far from the centre of the disc. It is clear that, *pro tanto*, the shadow is rendered smaller by falling near the outer parts of the disc; because these parts lie farther than the centre from the sun. Secondly, the elevation of the sun at the time of eclipse is not considerable. Since the sun is vertical at the place which occupies the centre of the earth's illuminated disc, and on the horizon for any place which lies on the circumference of that disc, it is obvious that when the track of the moon's shadow lies as in Fig. 1, the sun's elevation is relatively small during total obscuration. In the present eclipse, at the stations where the chief observing parties will be placed, the sun's elevation will be about 30 degrees, amply sufficient for ordinary observing purposes, but not altogether so great as might be desired for spectroscopic and polariscopic researches, and still less satisfactory for photography.

Fig. 2 presents on a larger scale the track of the moon's shadow, and the actual oval shape of the black spot which seen foreshortened in Fig. 1 appears as a circle. It will be seen that Odemira in Portugal, Cadiz and Xeres in Spain, Oran and Ratna in Africa, and Syracuse in Sicily, are the principal towns which lie very close to the central line. But it is probable that the stations will be selected without special reference to the proximity of towns; indeed for many purposes the less inhabited regions of a country are best suited for such observations as have to be made during eclipse.

Although Mount Etna is not very close to the central line, there are reasons for believing that a party stationed on the summit of this mountain would be enabled to make important observations. They would be more than twice as far raised above the sea-level as those observers were, who during the American eclipse obtained such favourable views of the solar corona from the summit of White Top Mountain. It will be remembered by our readers that General Myer reports the extension of the corona as seen from this station to have exceeded more than twofold the extension observed by those at lower levels. As there will probably be an English observing party near Syracuse, it would be a matter of the utmost interest and importance to compare their observations of the corona with those made at the summit of Etna.

At present, it may be mentioned in passing, there seems every reason to believe that two important expeditions will be sent from England to observe the eclipse. As we write, the arrangements are not complete, and there still remains a possibility that the whole undertaking may fall through. But it is hoped that this may not be the case, and that the large array of volunteers whose names appear in the list of the two proposed expeditions may be enabled to devote their energies to the work they have severally undertaken.

The main object of the astronomers of this and other countries will be to determine the nature of the corona. For this purpose, each of the English expeditions is to be divided into four parties. First, there will be the spectroscopists; secondly, the polariscopists; thirdly, the photographers; lastly, there are the general observers, who in our opinion are very far from forming the least important portion of the expedition.

The spectroscopic evidence obtained during the Indian and American eclipses is contradictory and unsatisfactory. Let it be remarked in passing, however, that it is not altogether so contradictory as has been asserted. The American observers appear to have been misled into the supposition that Major Tennant saw the ordinary solar spectrum—that is, that the Fraünhofer lines could be seen in the spectrum of the corona. And indeed in Prof. Roscoe's treatise 'On Spectrum Analysis,' it is stated that Major Tennant saw the ordinary solar spectrum, whereas "Professor Pickering, on the other hand, saw only a continuous spectrum." But Major Tennant's account expressly asserts that the spectrum he saw was continuous. He says, "*What I saw*" (the italics are his) "*was undoubtedly a continuous spectrum, and I saw no lines.* There may have been dark lines, of course, but with so faint a spectrum and the jaws of the slit wide apart, they might escape notice." Thus the continuous spectrum seen by some of the American observers is in perfect accordance with Major Tennant's observation. Indeed the mistake is rather fortunate than otherwise, because it led the American observers to search specially for dark lines such as they supposed Tennant to have seen; and, therefore, their failure to recognize any may be regarded as all but decisive of the matter.

Where Major Tennant's observations are *not* accordant with those made by the American observers, these latter observations are themselves wanting in accordance. For Professor Young saw three bright lines in the coronal spectrum, and Professor Harkness saw one bright line; whereas Professor Pickering, like Major Tennant in 1868, saw only a continuous spectrum. This discrepancy will, we may fairly trust, be cleared up during the approaching eclipse. It may perhaps be found that different parts of the corona give different spectra. It may be noticed, however, that the bright line seen by Harkness and the bright lines seen by Young were delicate objects, and would almost certainly have escaped notice had these observers used a much narrower or a much wider slit than they actually employed. Professor Harkness failed to see the line till he had slightly opened the slit; but he would probably have lost it equally had he widened the slit too much.* May not Major

* The total quantity of light from the bright lines would be increased by widening the slit; but the intrinsic brilliancy of the broadened bands would be no greater than before. On the other hand, the intrinsic brilliancy of the continuous background would be increased by the change.

Tennant have failed through such a course? He says, "thinking that want of light prevented my seeing the bright lines which I had fully expected to see on the lower strata of the corona, I opened the jaws of the slit." It is worth noticing that failure may arise from this very adjustment. Too narrow a slit is clearly unfavourable, because a certain quantity of light is required for distinct vision; but on the other hand too wide a slit is equally unfavourable, because a certain relative superiority in the brightness of the lines (or in this case *bands*) over the background of the continuous spectrum is equally requisite. The obvious conclusion is, that a telescope of large aperture and therefore of high light-gathering power should be employed, and the light of the continuous background reduced as much as possible by increasing the dispersion.

As respects the polariscopic operations, there is a similar contradiction to be explained during the approaching observations. The observers of the Indian eclipse assert positively that the light of the corona is polarized in a plane through the sun's centre; the American observers, on the other hand, as positively deny this. The Astronomer Royal (than whom no higher authority—on this particular subject—exists) solves the difficulty summarily by expressing his belief that the observers in India were not sufficiently familiar with the principles of polariscopic research to interpret what they saw. In this case, and assuming a similar state of things in the case of the American observers, we must look forward to the approaching eclipse as likely to supply the first really reliable information yet obtained respecting the polarization of the corona. We cannot doubt that the observers next December will not fail from want of knowledge, since not only has the Astronomer Royal called special attention to the necessity of their carefully preparing themselves beforehand, but the government of the party has been assigned to Professor Pritchard, who is nothing if not a master of the science of theoretical optics. Our great fear is, however, lest the methods of testing light at present in vogue may not be sufficiently effective for the resolution of the somewhat difficult problems depending on the polarization of the corona. Whatever advantage there may ordinarily be in the use of well-tried methods, it may be questioned whether in this particular case more powerful instruments than the polariscopes at present in use might not be devised and employed with advantage.

We pass over the photographic department of the expedition; in the first place because there is every reason to feel confidence that under the able supervision of Messrs. Browning and Brothers (at Gibraltar and Syracuse respectively) the photographic arrangements will be exceptionally successful, and in the second because as regards the inquiry, which is the main purpose of the expedition, photography can teach us comparatively little. Unless the whole

duration of totality were given to a single negative—which would be clearly unwise—no satisfactory picture of the corona could be obtained.

The chief promise of the expedition, in our opinion, lies in the number of skilled observers who have joined the two parties which are to devote their energies to general observation. The names of Mr. Lassell, Lieut.-Colonel Strange, and others (it is almost invidious to particularize), afford a sufficient guarantee not only of skilful observation, but also of a thoughtful study beforehand of the *modes* of observation likely to be most successful. We cannot suppose for a moment that such observers will be content merely to renew the observations which have been made so often and to such little purpose,—to tell us merely the oft-told tale respecting the beauty and splendour of the corona, its colour, extent, shape, and so on. Something much more definite is required, and that something, if it can be obtained (of which we have no doubt whatever), is surely to be expected from the skilful astronomers who have promised to take part in the general observations to be made on the corona.

Let us consider a few of those points on which it is most desirable that information should be obtained.

It has been observed by some astronomers that the structure of the corona seems in places to be marked by the presence of curves and striations, and sometimes even of complex portions, which have been compared to "hanks of thread in disorder." It is most important that adequate telescopic power should be applied to determine how far this appearance is real, and what peculiarities may be recognized in the curves, hanks, and striations, under telescopic scrutiny. For this purpose the disc of the moon ought not to occupy (as has been usually the case) the centre of a large field; but the brighter part of the corona close by the moon's limb should be kept altogether out of the field of view. Further, different powers should be employed, and the focussing for each should be very carefully noted. For even those who reject wholly (as we confess that we do) the theory that the corona is merely a phenomenon of the earth's atmosphere, must recognize the fact that the appearance of the corona may be, and probably is, very much affected by our atmosphere, through which it is necessarily seen. So that some of the peculiarities which apparently belong to the corona may in reality appertain to our own atmosphere. In this case the focussing suitable for clear recognition of the causes of such peculiarities would correspond to the relatively small distance of the upper parts of our atmosphere, and would thus differ appreciably from the focussing for celestial objects. It has been suggested that "the use of a telescope of low magnifying power but first-rate definition, a comet eye-piece being employed, would be desirable in

studying the corona. The telescope should be accurately driven by clockwork, and a dark iris-disc, if one may so describe an arrangement which would be the converse of an iris-diaphragm, might be employed with advantage to hide the light of the prominences and chromosphere. If the field of view were several degrees in diameter, and the dark disc at the beginning of totality concealed a circular space extending a degree or so beyond the eclipsed sun, the observer might first examine with great advantage the outer parts of the corona, and gradually extend his scrutiny to the very neighbourhood of the prominences."

A question of extreme importance, which seems fairly within the range of the available modes of research, consists in the determination whether the outer and extremely faint parts of the corona show any sign of prolongation towards those regions where, as we know, the zodiacal light extends. The whole of that portion of the heavens along which (speaking with reference to the place of the sun) the zodiacal light is ordinarily visible, is above the horizon during most total eclipses. Further, the dark region corresponding to the place occupied by the moon's shadow in our atmosphere, extends at the beginning and end of totality over a very wide range of sky, first on the western and then on the eastern side of the lunar disc. Along this region the faint glow of the zodiacal light ought to be perceptible if sought for under favourable circumstances. Among such circumstances are, of course, a clear sky and an elevated station. But there is one condition which, so far as we know, has never yet been attended to. The maximum darkness of a solar eclipse comes on so rapidly that the eye is yet dazzled by the light when totality is in progress. Nor does totality last long enough for the eye to acquire the power of recognizing faint differences of illumination. This fact serves to explain the failure of observers, hitherto, in detecting the delicate phenomenon we are now considering. There appears to be good reason for believing that the search would be conducted with a much better prospect of success if the observer who undertook it were in the first place to keep his eyes as much as possible in darkness until totality had fairly commenced; and in the second, to hide the whole of the corona from view while searching for the zodiacal light. This could be very easily managed by arranging beforehand a black disc so as to conceal the sun at the time of totality from an eye placed at a certain aperture, through which the observer should conduct his search, during totality, for the faint light along the ecliptic. This method seems so promising, and the inquiry itself is so full of interest, that we cannot but hope some observer will be willing to devote himself specially to this particular subject.

But we may safely expect from those who have volunteered to take part in an expedition which will probably be by no means a

pleasure trip (remembering the season and the nature of the voyage) the thoughtful consideration beforehand of all those means by which the expedition may be made successful. They will be fully aware that the astronomical world will expect from them something more than the renewal and confirmation of former observations. We may hope from them therefore results of extreme interest, throwing new light on important problems of solar physics, and perchance even revealing unexpected truths respecting the economy of the solar system itself.

VI. THE CONTROVERSY ON SPONTANEOUS GENERATION: WITH RECENT EXPERIMENTS.

By James Samuelson, Editor.

There is perhaps no biological question, excepting the origin of species, which has been so warmly debated in England and abroad, as the mode in which the lowest known types of animal and plant life come into existence, and probably one reason why these inquiries have been productive of so much excitement, is their indirect theological bearing.

The developmental theory recently elucidated by the researches and arguments of Darwin gave a fatal blow to the ancient beliefs concerning the first appearance and presence of the animal and plant races on the earth's surface, and rendered unnecessary the special intervention of the Creator to account for the production of new species; whilst the hypothesis of spontaneous generation, or the creation *de novo*, in organic infusions of the lowest known types of plants and animals in our time, seems, to impetuous and superficial thinkers, to put the divine influence altogether out of sight, and almost to degrade what have hitherto been regarded as living beings and vital forces to a level with the unconscious physical forces and inert forms of matter.

With these considerations, however, scientific men have no concern, and whether or not the creation of a living thing from organic or inorganic materials, by what may be termed artificial means, be regarded as a sacrilege, the investigation must be undertaken without apprehension or prejudice, and the verdict given, not by theology or theologians, but on the evidence of strict experimental research, and from unprejudiced inductive reasoning.

Scientific men being, as a rule, regarded as ruthless iconoclasts, anxious only to lacerate the feelings and undermine the most sacred aspirations of true believers, it may be supposed that these remarks are prefatory to an argument intended to overturn all our preconceived views as to the higher nature of life, and to hand over the

Fig. 1.

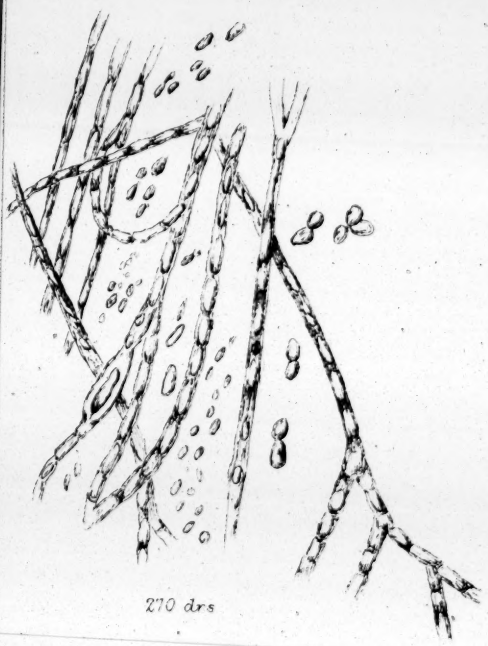


Fig. 2

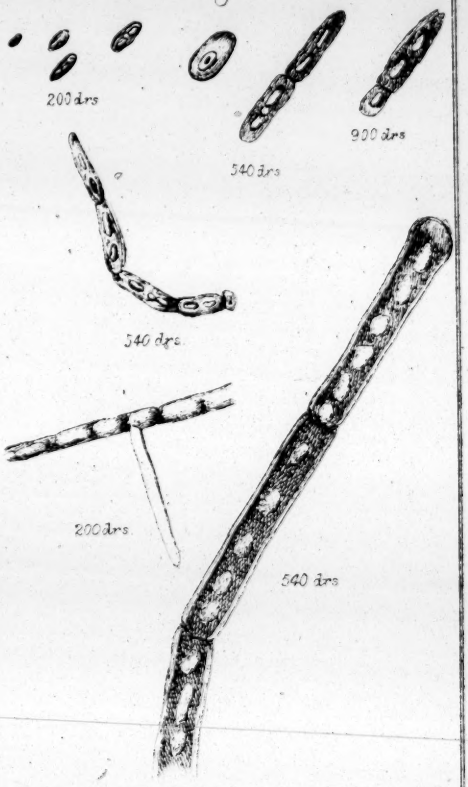


Fig. 4

Fig. 3.

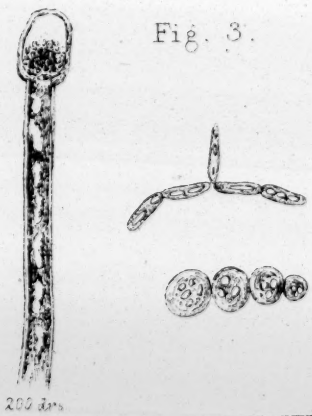
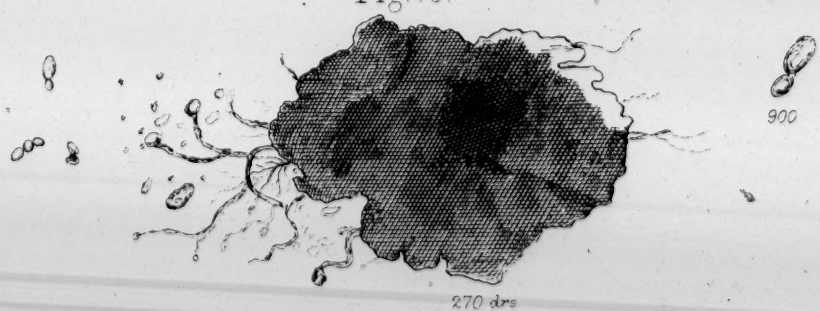


Fig. 5.



Lith. Whiteman & Bass. London.

Organisms found in infusion of Orangejuice, and in pure Rain Water.

task of creating living beings to the chapter of accidents and to the blind physical forces of nature. My task is, however, not of such a painful character. In the first place, it must be remembered that if it should turn out that living beings are capable of springing into existence through the direct transformation of decaying organic matter, those beings are, so to speak, merely the instruments upon which the higher psychical faculties play; from dust they come and to dust they return. And again, every advanced thinker is prepared to admit that even the higher races which animate, beautify, or transform the earth's surface, are fed, grow, and decay through the direct operation of the physical forces, and that they are exquisitely constructed machines, liable to injury, accident, and destruction, and need fuel and reparation just as any humanly-constructed mechanism. What difference, then, can it make to any but the most timid or bigoted thinkers whether the first appearance of the lowest types of animal and plant life is due to the direct action of the physical forces upon matter which has once been organized and is undergoing decomposition, or to the same forces or some unknown modification of them acting in the first instance in or upon almost inconceivably minute pre-existing germs?

I can, however, offer to such timid philosophers the crumb of comfort, that it is not unlikely the ultimate result of the discussion which now agitates the scientific world will be to show that the lowest known living types are *not* now created *de novo*, but that their germs are almost omnipresent and ineradicable; and this conclusion has been arrived at by me, not from the experiments with varying and contradictory results which have been tried by different investigators, but from a calm consideration of the whole question, renewed at intervals, over a space of nearly fifteen years.

And this reflection causes me to draw attention to a peculiar circumstance connected with the controversy on spontaneous generation; namely, that we hardly ever hear of the work of any observer extending over a lengthened period. In most cases we have a set of experiments tried by an investigator of greater or less eminence now a zoologist, then a chemist, which are published along with his views, usually of a very decided and dogmatic character, and then he rushes out of the arena, and we hear nothing more of him on that subject. Of course he has settled the question to his own satisfaction and to the satisfaction of those who agree with him, and there is no need of further investigation until some new circumstance or some fresh set of experiments invalidates all previous evidence and raises up a new host of combatants and disciples on either side.

We are at present in the very thick of such an intellectual contest, and no doubt there are many true believers in heterogenesis who regard as conclusive the recently-published experiments and observations of Dr. Bastian which have startled the boldest thinkers and

some of the most profound biologists; but after bestowing upon them the careful consideration which they well deserve, and trying such experiments as seemed to me to throw light upon some of the mysterious appearances described by him, I have come to the conclusion that, so far as he is concerned, the argument stands just where it was, and that the question is likely to remain an open one for a long time to come.

Many will, no doubt, remember that some years since Professor Huxley, influenced by the astounding revelations of organic chemistry, and by the facility with which one form of organic matter after another was being synthetically produced by chemists in their laboratories, ventured on the bold speculation that *possibly* experimentalists might one day be able "to take inorganic matters such as carbonic acid, ammonia, water, and salines in any sort of inorganic combination, and be able to build them up into protein matter, and then that that protein matter ought to begin to live in an organic form;"* but Dr. Bastian believes that he has accomplished even more than this, that he has taken solutions of saline substances in proportions which he details most circumstantially, has exterminated in them all the germs which they might possibly be said to contain, and by excluding the atmosphere has prevented the entrance of new ones which might be said to be floating in that medium; and that, yet, after intervals varying from nine or ten to forty days there have been spontaneously produced in and from those substances, not particles of protoplasm as it was hinted possible by Professor Huxley, but truly organized plants and small ciliated infusoria.

But, in the first place, his own account of these experiments is often very vague. For example, he tells us† that he prepared a solution of crystallized white sugar, tartrate of ammonia, phosphate of ammonia, and phosphate of soda, which was boiled for twenty minutes and kept *in vacuo* nine days; and, to use his own words, "when examined microscopically a few monads and bacteria were found in the first drops of the liquid which had been poured out before the whole was shaken."

So far, after nine days' exposure he found only what has been seen by a score of observers over and over again, and cautious investigators, such as Dr. Child, Dr. Beale, and others (as I ventured years since to predict), have refused to admit many of these minute moving specks to be living organisms at all. But he goes on to say, "The remainder was then poured into a conical glass, and after having been allowed to stand for a time, the supernatant fluid was removed and the last few drops containing the sediment were

* 'On our Knowledge of the Causes of the Phenomena of Organic Nature;' being Six Lectures to Working Men. By Professor Huxley, F.R.S. London: R. Hardwicke.

† 'Nature,' July 7, pp. 195–6.

examined." It is to be regretted that we are not informed how long the fluid was allowed to stand exposed to the air, for although in the case under consideration the only result of the exposure was the appearance of many "bacteroid particles" (whatever that may mean—for a bacterium itself is the minutest speck perceptible to the eye with high microscopic powers), "and monads of different sizes exhibiting the most active movements," yet I will show presently, that when certain fresh infusions are exposed under favourable circumstances only for a few hours, they become filled with perfectly-organized plant forms in different stages of growth. In addition to those "bacteroid" particles and monads, Dr. Bastian also found "irregular-shaped particles" which were active, and the conclusion at which I am constrained to arrive, is that his enthusiasm in the cause of heterogenesis has led him, there at least, to confound the atomic motion of organic and inorganic particles with the movements of similar objects, of which it is always necessary to trace the growth and development before they can be safely pronounced to be the germs of infusoria or of lowly plants.

Let me, in passing, recommend those investigators who are reviving the experiments of Pouchet, Pasteur, Schulze, Joly, Musset, Wyman, and others, all of whom have failed to convince the scientific world, that they should not only examine their infusions, as heretofore, some *days* after they have been sealed up, but some hours afterwards, and I have reason to believe that the comparison will change their views as to the result of closing and preserving those infusions.

Again, some of Dr. Bastian's experiments are strikingly adverse to the hypothesis that the types observed and described were created *de novo*. In experiment No. 13, a solution of tartrate of ammonia and phosphate of soda, which had been kept twenty days *in vacuo*, was found to contain a fungus, &c., whilst another solution, which had been prepared in the same manner and at the same time, was opened on the thirty-fifth day, and "yielded no organisms of any kind;" but mark! when a third solution of the identical substances was so treated as to give free access to the air, and was examined on the thirty-eighth day, there was found what the observer calls "a spirally-twisted organism." It seems to me that it would hardly be possible to adduce more convincing evidence against heterogenesis and in favour of the atmospheric germ theory than is afforded by these results, and a very striking confirmation of this view is to be found in a circumstance which has recently been discovered in another quarter, affording evidence, all the more valuable, because it was not intended to influence this controversy. Mr. Wood, of Middlesbrough, in his efforts to preserve tartaric acid solutions in a state fit for chemical experiments, has found that whilst such a solution will, under ordinary circum-

stances, become mouldy, it will not undergo that change if previously boiled and filtered—but it must in fairness be added that he says, even if exposed to the air. Whether he means constantly exposed to the air, or only occasionally, I am unable to say. How such substances become mouldy will be seen presently, and it will be found to have a direct bearing on the argument.

Before proceeding to describe my own recent investigations, however, I desire to make one more reference to the published opinions of Dr. Bastian, to show how necessary it is to be cautious before we construe the microscopical appearances connected with this inquiry.

In speaking of the pellicle which appears on the surface of infusions, Dr. Bastian says,* "What Burdach named the proligerous pellicle of organic solutions, is made up of an aggregation of monads and bacteria in a transparent jelly-like stratum on the surface of the fluid. It constitutes at first a thin scum-like layer, and although the monads and bacteria entering into its composition are motionless, M. Pouchet and others were not warranted in assuming from this fact alone that they were dead. There is indeed good reason for believing to the contrary, since, as pointed out by Cohn, when any of these particles are set free from the broken edge of a pellicle, they always resume their movements. Motion, therefore, may simply be prevented by the presence of the transparent jelly-like material in which they are imbedded, although the particles may be undoubtedly living."

Under what circumstances the observers examined this so-called "proligerous pellicle," I am unable to say, and Dr. Bastian himself says, that owing to his observations being carried on in winter, he was not able to witness those changes observed by Pouchet; but he describes certain other changes in this pellicle on infusions which, according to his account, resulted in the development of unicellular organisms.

Now, with all deference to the eminent observers quoted by Dr. Bastian, I venture to say that the appearances referred to have no bearing whatever upon the controversy, inasmuch as they are by no means confined to infusions.

Long before I had heard the expression "proligerous pellicle," or was aware that this phenomenon was supposed by the advocates of heterogenesis to precede the creation, *de novo*, of living forms, I had myself observed a precisely similar appearance in pure distilled water exposed to the atmosphere. This was recorded at the time, as follows, in a paper read before Section D of the British Association in 1863:—

"Let me, however, briefly refer to the results of the exposure of distilled water only, in July, for that experiment has not been re-

* 'Nature,' June 30, p. 172.

peated with such satisfactory results. The glasses containing the water were so placed in a box divided by three partitions and covered with lids of blue, red, and yellow glass, that the panes intercepted all dust falling perpendicularly, and for several days very little dust reached the contained water. A deposit of dust had meanwhile accumulated on the panes of glass. Finding little or no life in the distilled water, I washed the dust from the glass lids into the respective vessels, and on the following day repeated the examination. As usual, I observed particles of silex and fragments of organic substances, and, with a low power, these seemed to be imbedded in a gelatinous film. I had placed the little glass vessels themselves under the instrument, and after pouring off the water, examined the deposit with a power of about fifty diameters. On covering the sediment with a thin glass, and bringing a higher power to bear, I found the gelatinous film to consist of motionless transparent monads or cells, and carefully restoring the contents of the vessels, pouring back the water, I left them until the following day. During the night and day, the cells or monads had become endowed with rapid motion, and an examination of the water showed it to be peopled with myriads of active moving germs."

Here, then, is another phenomenon supposed to be attendant upon the creation *de novo* of lowly organisms in infusions, which I had observed and recorded years since in pure distilled water exposed to atmospheric action.

And this brings me to my recent investigations, conducted during the months of June, July, and August last. As considerable doubt has been thrown upon the existence of germs in the atmosphere by certain observers, in their anxiety to prove the spontaneous production of the lowest plants and animals, I first repeated my former simple experiments with distilled water, and this time I used open saucers, small glass well-dishes (those used to hold ink), and even test tubes.

On the 21st June I first exposed two saucers of distilled water to the air, and two days afterwards I found it to contain a little sediment of dust. On examination with the microscope, a drop of the water presented the appearance so frequently described by me. There were fragments of silex, soot, and minute moving germs. The latter I shall not attempt to dignify with scientific names; suffice it to say that the contrast between their movements and the molecular motions of particles of organic and inorganic matter afforded sufficient proof of their being endowed with life. I then filled two test-tubes with portions of this water, closed the opening of one with a sheet of cotton-wool, and left the other exposed to the air. From the 23rd June to the 5th July the weather was cold and rainy, conditions very unfavourable for the development of living germs; but between the 5th and 7th July the temperature

had risen considerably, and I then examined the tubes. (It should be added that I had in the meantime added distilled water to that in the open tube to compensate for evaporation.)

The exposed water contained numerous zoospores, and unicellular forms. Some of these were quiescent and attached together in clusters; others in active motion. There were some small amœbæ, small particles of protoplasm, with elastic cell-walls, well known to micro-zoologists. In these, not only the characteristic changing prolongations were visible, but I clearly followed the rhythmical movements of the contractile vesicle. From the other tube, the cotton-wool appeared to have excluded the dust and germs—the former having collected on the cotton, for I found no organisms of any kind. It is right, however, to mention that cotton-wool does not permanently exclude the germs; and in another case, where the conditions of development were favourable (if the view be correct that they are conveyed by the atmosphere), it will be found that the substance referred to failed to exclude them.

As to my saucers of distilled water, on going to examine them I found the contents dried up, but a considerable quantity of dust remained. This I scraped together; retained it until my return from a journey on the 19th July, and then submitted it to the following process in the laboratory of my friend Mr. Tate, of Liverpool, aided by his assistant:—

First we heated the dry dust in an open tube to 480° C., and then, allowing it to cool, we heated it again to 280° C. It had then caked, and after loosening it with a wire we added distilled water, and boiled it for a few minutes. Then I closed the tube containing the liquid temporarily with a little stopper of cotton-wool.

The same evening, on examining the sediment with a power of 200 diameters, I observed many of the appearances described by investigators who have opened infusions after they have been kept *in vacuo* several days; some, for example, similar to those described by Dr. Bastian in his first experiment recorded in 'Nature' of July 7th. But I did not feel justified in attributing the movements of the particles to their being endowed with life.

I then divided the chief part of the water containing the dust into two tubes, closing one with cotton-wool and leaving the other exposed, and a little of it was left in an open wine-glass. The open tube I examined on the 22nd, 23rd, and 24th July. The temperature was very high—82° in the shade—and the development of the little *Cercomonas*, so frequently described by me in former years* was very rapid, so that on the 25th its movements were clearly traceable amongst other lowly types.

The water in the wine-glass was again dried up, but the effect

* 'Journal of Science,' vol. i., p. 607, and elsewhere.

of the high temperature was surprising, and two hours after I had added a little distilled water to the dust I found it to contain clearly-defined and active monads and other living types. I may here mention that the very warmth of the hand in which the slide is held will often render active and instinct with life little unicellular organisms which, on being first examined with the microscope, appear inanimate and motionless.

On the 28th and 29th July I again examined the tubes, opening the closed one on the latter day, and found that although the number of forms in that was much less than in the one that had been exposed, they were alike in character, and I showed to two astonished visitors who had never seen such appearances, active *amœbæ* in water taken from both tubes.

Here my experiments with pure distilled water terminated, and, so far, they are not only confirmatory of what had been observed and described by me many years since, but they satisfied me that the solid floating contents of the atmosphere may be submitted to an exceedingly high temperature in the dry as well as moist condition without exterminating the living germs; and that when distilled water is added and the sediment is examined, either immediately or after a few days' exposure, even if the air has been excluded, it exhibits most of the phenomena believed by the advocates of heterogenesis to be proper to infusions which have been boiled and kept *in vacuo*.

And now I have to describe a second set of experiments, which may perhaps serve to throw light upon the appearance of those fungi which are frequently found upon decaying substances in the form of mould or mildew, and which Dr. Bastian believes he has been instrumental in creating spontaneously in organic and inorganic infusions. Two announcements recently made by the advocates of heterogenesis influenced the direction taken by my investigations. One was the statement contained in Dr. Bastian's account of his experiment No. 5,* that he had discovered in an infusion of turnip *in vacuo* which had been hermetically sealed five days, a reticulated substance which he calls "Leptothrix' filaments. The other was the discovery by Mr. Wanklyn, the chemist, of sufficient albuminous matter in a pint of air to render it highly probable, from that circumstance alone, that the atmosphere is charged with living germs. Mr. Wanklyn strangely enough cites his discovery, triumphantly, as conclusive evidence of the absence of such germs, inasmuch as the quantity of albuminous matter was found to be very insignificant; but Dr. Beale, one of our most experienced microscopical observers, has expressed the view † that Mr. Wanklyn has found a volume of such matter, which, insignificant as it may appear, renders it highly probable that of the air tested by him "not a

* Reported in 'Nature,' July 7.

† 'Nature,' July 28, p. 255.

thimbleful could be taken without containing several" germs. Mr. Wanklyn's evidence certainly reads very much like that of a scientific witness for the defence in a case of murder, who seeks to show that the deed could not possibly have been committed upon a certain clean deal floor where it is said to have been perpetrated, inasmuch as he had carefully examined a square inch of the floor, and had only discovered the minutest spot of blood!

As to the "Leptothrix" which Dr. Bastian found in turnip-juice, I may mention in passing that it is considered by microscopic botanists to consist of the mycelial filaments of mildew fungi,* and I believe from my own investigations, to be described presently, that if he had followed the growth of his "Leptothrix" he would have found it to be one of those plants. Now these mildew fungi are found not only in and upon decaying organic matters, but also upon bare stones and rocks, where they cannot be created *de novo*, but must necessarily result from atmospheric spores moistened by showers of rain. Coupled with the two circumstances just mentioned, the account given by Dr. Angus Smith of his mode of testing atmospheric air opened out to me a new field of inquiry. Dr. Smith's system of washing the air is admitted to be tedious and imperfect, though it may be the best in the cases with which he deals; but it seemed to me that no better method could be devised for ascertaining the nature of those substances which are held in suspension in the atmosphere than the one which nature provides in the form of rain collected as it falls from the clouds.

Two circumstances are well established as regards falling rain. The first is that at the commencement of a shower after a long-continued drought the rain brings down much more organic and inorganic matter than later on; and secondly, that after a heavy shower the atmosphere is for some time comparatively free from such matters.

Then as regards the discovery of filaments in infusions, I had tried some experiments with infusions of orange-juice, orange-peel, apple-juice, and cabbage-juice, in distilled water, freely exposed to atmospheric influences, in 1862 and 1863, and when Dr. Bastian's observations were published I recollected having found such a mycelium in orange-juice, and having corresponded with Professor Hoffmann about it, but as he could throw no light upon the appearance of the mycelium and I was unable to account for it, I dropped the investigations. A record of these observations was however kept, and was discovered by me amongst some old papers whilst I was making the following experiments, and they will now be found of some service.

On the 4th of August, after a long continuance of intensely hot weather, we had a violent thunderstorm. I had been expecting

* 'Micrographic Dictionary' (Van Voorst), article "Leptothrix."

and preparing for this, and at once proceeded to catch the rain as it fell, and at the same time to prepare an infusion of filtered orange-juice *in pure distilled water*. This infusion I divided between two glass-wells, one of which I closed with cotton-wool, whilst the other was freely exposed to the atmosphere; and side by side with these I placed a tall champagne glass full of the rain-water which I had collected during the shower, and which contained numerous particles of dust.

None of these liquids showed any undoubted signs of life when I examined them with the microscope, before exposure. The infusion contained organic yellow particles; the rain-water organic particles, fragments of minerals, empty sheaths, empty cell-walls, and minute moving specks.

The very next day, however, August 5th, I was astonished to find in the open infusion of orange-juice the mycelium figured and described by Dr. Bastian as having been present in his infusion of turnips, or one closely resembling it; and in my infusion it was accompanied by innumerable minute unicellular oval organisms, the careful examination of which satisfied me beyond a doubt that they were an earlier stage of the thread-like filaments. Some of them were single, others were undergoing subdivision into two or more segments, whilst on the other hand some of the filaments were giving off cells exactly resembling the smaller detached ones.

During a long course of microscopical observation of biological changes, I never was so much astonished as on that occasion to find with what rapidity Nature (or that I may not be misunderstood—Nature's Ruler) brings back to active life the decomposing materials which have been its previous stronghold; and had I been led away by momentary impressions I could not have conceived it possible that the change had been produced in that case by any other process than heterogenesis, or the elevation of a portion of the organic infusion into organized types, without the auxiliary influence of pre-existing germs. But a little reflection reminded me that it is just these first surprises and impulses which lead men to disseminate erroneous views, as it was no doubt the extraordinary appearance of maggots and flies on some decaying carcase which gave rise to the idea of those insects being spontaneously generated there. I therefore contented myself with figuring the cells and the mycelium as they appeared under varying powers of the microscope on the day in question and the four following days (Figs. 1 and 2), and during that time the mycelium gradually developed into a true mould or mildew fungus, some of which floated on the surface. At the same time numerous ciliated infusoria made their appearance.

On the 9th August I opened the other glass-well containing the infusion, and found it covered in like manner with mildew. I

carefully removed a portion and delineated one of the dry full-grown filaments with a cluster of spores in its spore-case at the extremity (Fig. 3). Of course I was surprised to find the progress which had been made in this closed infusion, but on consideration it soon occurred to me that if on the one hand the ingress of the first germs was impeded by the cotton-wool, on the other, the same agency prevented their egress when they were produced there, and compelled them to fructify in the vessel in which they were confined; and moreover, whilst I had been daily disturbing the organizations in the open vessel, and adding distilled water to compensate for evaporation, the other had remained undisturbed during the whole period.

Then on examining, for the first time after exposure, the rain-water in the champagne glass, I there discovered large numbers of the same unicellular organisms as in the two infusions, some single, others undergoing subdivision, precisely as in the cases described (Fig. 4), and the natural inference to be drawn from this circumstance would be, of course, that the mildew fungi were the result, not of spontaneous generation, but of the introduction of germs from without. But here again it was necessary to exercise caution before coming to a conclusion. In the first place, the very fact which I have been trying to demonstrate, *viz.* the existence of innumerable atmospheric germs, at once suggested the probability that the germs in the rain-water which stood close to the infusions might have been wafted into it from the fungi growing in those infusions. And secondly, the slightest residuum in my dipping tubes, which I might not have cleansed properly, would suffice to account for the appearance of these cells. These doubts were partly cleared up at once.

On tasting the infusion which had been covered with cotton, I found signs of acid fermentation, and I examined drops from the surface as well as from the bottom of the liquid, for recent investigations on another subject had taught me that during such fermentation the biological phenomena vary in different parts of the fluid. At the bottom of the fluid I found clusters of large globular cells (Fig. 6), and on or near the surface groups of smaller elongated ones (Fig. 5). I was at once induced to compare these with the cells of the yeast fungus (*Torula cerivisiæ*) which are delineated in the 'Micrographic Dictionary,' and were said to have been found by the observer at the bottom and on the surface of fresh brewer's wort in which fermentation had just commenced. I could hardly find any difference between the two sets of cells, and in both cases those from the bottom of the fluid were round, whilst the surface cells were elongated. This is of course no proof of identity; and although I strongly suspected that in the one case as in the other the germs had been introduced from without, I

guarded myself from considering this as more than *prima facie* evidence. Another circumstance tended to show the correctness of this observation.

I had just found the notes of my experiments with infusions in 1863; and these entries had been made in connection with the infusion of orange-juice:—

"Aug. 3. Mycelium with minute cells."

"Like yeast-cells, 'Micr. Dict.,' Plate 20, Fig. 23."

"Aug. 7. The flocculent deposit tastes like mould." "No acid taste."

This description and the sketches which accompany it leave me in no doubt that the appearances were precisely those which I had observed last month, and the Plate and Fig. referred to in the 'Micrographic Dictionary' are strangely enough the same as I had a second time consulted after an interval of seven years, and which will be found copied in an article recently published by me on the manufacture of Beer.*

The same notes contained the following entries:—

1. In regard to an infusion of cabbage-juice exposed July 27th, and examined August 2nd—

"Homogeneous cellules.—Little or no motion, and nothing to indicate whether they were spontaneously produced from cabbage. *Closely resembled sessile monads in dust exposed under coloured glasses.* See paper before Academy" (des Sciences).

2. Concerning *pure distilled water* exposed August 2nd, 1863, examined 7th (temperature 70°)—

"*A little mycelium, same as in organic matters.*"

The only difficulty I experienced was this. It seemed to me incredible that the same specific germs which (as I believed) had floated in the atmosphere in 1863, and had then found their way into and had become developed in infusions of orange and cabbage juice as well as in distilled water, should again be present in an infusion of orange-juice and in distilled water in 1870, but a further investigation soon decided the matter.

On the 22nd of August last, again, after continued warm dry weather, the rain set in, and during the first hour I succeeded in catching some direct from the clouds in two distinct localities: at my own house, which is in Everton, at the very outskirts of Liverpool, with gardens about, and trees and fields close at hand; and also in Vauxhall Road, one of the most unhealthy of the lower parts of the town, where, notwithstanding the efforts of the sanitary authorities, the atmosphere is charged with smoke and other emanations from factory chimneys.

* "Beer:" see 'Journal of Science,' July, 1870.

On examining the rain which had fallen in both these localities I found, naturally enough, no animal or plant germs in that from the lower part of the town, although it was highly charged with soot and various kinds of dirt; but in that which had been collected near my house, I found on the same day a few of the unicellular organisms as before, some single, others undergoing sub-division; also a little soot and silex. On the following day I expected these germs would have sprouted, and I was not mistaken. I had cleansed my tubes well with sulphuric acid, after having made them red-hot, and had taken every possible precaution to avoid fusion of the fluids or their contents; but the result was unmistakable. The particles of soot and silex were present in the Vauxhall Road water, but no germs of any kind, nor any mycelium; whilst that caught in Everton was full of unicellular organisms in various stages of growth and sub-division, and the particles of soot had become beds, as it were, in which the germs were sprouting, for out of them grew fibrous filaments precisely resembling those which I had first observed in the infusions (Fig. 7). On the 24th (the following day) these filaments had assumed the form of a straggling mycelium, not so thick as in the former infusions, and not so much interlaced, but the identity of the organisms was quite undoubted. There were also swarms of minute rapidly-moving infusorial germs along with somewhat larger ciliated infusoria.

Coupling, then, my experiments of former years with those recently tried by me, the results, as far as they bear on this controversy, are as follows:—

In 1863. I found in infusions of orange and cabbage juice the germs and mycelium, which constitute the earlier stages of mildew fungi, and at the same time I found those lowly plant forms in pure distilled water which had been exposed to the atmosphere. Recently I again found this plant type in an infusion of orange-juice, and traced its growth into a mildew fungus. I also found it in pure distilled water, and afterwards, well developed, in rain-water caught as it fell direct from the clouds. This plant, or one closely allied to it, Dr. Bastian believes to have been spontaneously generated in an infusion of turnip-juice contained *in vacuo* in a closed tube.

Again in 1862–3. Dr. Balbiani in Paris, and I in Liverpool, found simultaneously in pure distilled water exposed to the atmosphere, and in dust taken from window-panes and elsewhere, various infusorial animalculæ, especially one well-defined type, which I have again recently found in pure distilled water, and in dust which had been submitted to a high temperature. And that such animal germs are present in the atmosphere in all parts of the world, I showed some years since, by submitting to microscopical observa-

tion the dust shaken from rags which had been picked up in the streets of Tunis, Trieste, Melbourne, Bombay, and other places from which such rags are imported. These animal types, too, are believed by some to be spontaneously created in infusions.

Here I leave to the judgment of men of science the results of my experiments, which any boy possessed of a microscope may repeat as effectually as I have performed them. And if the believers in spontaneous generation still insist that their hypothesis has not been refuted, and that, assuming my observations to be correct, their view of the case has not been fully disproved, I am not prepared to deny this; but on the other hand I must be permitted to retort that *their* experiments have only proved, so far, their inability, notwithstanding all their precautions, to exclude invisible germs from their infusions. As to the mysterious appearance of these microscopical types on their solutions *in vacuo*, what is it compared with the presence of some of the internal parasites of man and the lower animals? And who would have credited twenty years since, the story of the wanderings and metamorphoses which those forms undergo before they find their way into the final habitat designed for them by Nature? There is, however, very little chance of the controversy coming to an end at present. It is fascinating and exciting, and in so far quite in accordance with the spirit of the age. Nor is it desirable that it should cease, for it is causing microscopical observers to direct their attention more and more to the beginnings of life, and to the development of those living types which are visible only with the aid of the lens; and I know of no subject more worthy of the consideration of biologists.

VII. THE DEVONSHIRE ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, LITERATURE, AND ART.

Early in 1862, it occurred to a few scientific men, residents in Devonshire, that they might with advantage establish in their own county an institution resembling the British Association, of which they had for several years been more or less active members. The idea having been favourably received in some of the principal towns of the county, a meeting was held at Plymouth, which, though not largely attended, was thought to be of sufficient weight to inaugurate the proposed Association, to draw up a provisional constitution, to elect officers for the first year, and to announce that the first annual meeting would be held at Exeter on the 14th and 15th of August, 1862.

From that time, meetings have been annually held in different

towns of the county, the number of members and of papers have steadily increased, and several distinguished men have accepted the office of President. In short, the Association is not only well established in the county, but it is also fully and cordially recognized by the scientific world generally.

We proceed to give a brief sketch of its history, constitution, and operations, believing that there would be little or no difficulty, and very great advantage, in establishing kindred institutions in the other counties of the kingdom.

Being limited to a single county, it was decided not to restrict it to science. It was accordingly named "The Devonshire Association for the Advancement of Science, Literature, and Art," and its objects were declared to be "To give a stronger impulse and a more systematic direction to scientific inquiry in Devonshire; and to promote the intercourse of those who cultivate science, literature, or art, in different parts of the county." There can be no doubt that this decision was wise, as it was calculated to enlist a greater number of members, and to secure more numerous and a greater variety of papers, whilst it enabled men who might otherwise regard themselves as unqualified, to accept the office of President.

The number of members has steadily increased from 69 in 1862 to little short of 300 at present; and almost every part of the county is represented by them.

Each member pays ten shillings annually, or a life composition of five pounds, and is entitled to tickets of admission for himself and a lady, as well as to a copy of the annual 'Transactions.' Not only has this small sum been found sufficient to cover all expenses, but at the meeting held on July 26th, 27th, and 28th, of the present year (1870), under the presidency of Mr. J. A. Froude, the eminent historian, the treasurer reported a balance in hand of upwards of ninety pounds, besides property, in the form of 'Transactions' in stock, to the amount of upwards of one hundred and sixty pounds.

As the Association was not established for the purpose of accumulating money, there is reason to hope that it may very shortly be in a position to vote small sums for the purpose of conducting or aiding researches within the county. Devonshire, it is well known, is rich in bone caverns and barrows which would well repay investigation, and its moorlands abound in megalithic structures, of which at least accurate models should be made and placed in the museums at Exeter, Plymouth, Torquay, and Barnstaple.

The Presidents are ineligible for re-election. The following is the entire list, as well as of the dates and places of meeting, from the beginning:—

Dates.	Places.	Presidents.
1862, August 14th	Exeter	Sir J. Bowring, LL.D., F.R.S.
1863, July 29th	Plymouth ..	Mr. C. Spence Bate, F.R.S., F.L.S.
1864, July 20th	Torquay ..	Mr. E. Vivian, M.A.
1865, June 28th	Tiverton ..	Prof. Daubeny, M.D., F.R.S.
1866, August 8th	Tavistock ..	Earl Russell, K.G., F.R.S.
1867, July 23rd	Barnstaple ..	Mr. W. Pengelly, F.R.S., F.G.S.
1868, July 28th	Honiton ..	Sir J. D. Coleridge, M.A., Q.C.
1869, July 20th	Dartmouth ..	Mr. G. P. Bidder, C.E.
1870, July 26th	Devonport ..	Mr. J. A. Froude, M.A.

The earlier part of the first day of each annual meeting is devoted to business, and in the evening the President delivers his address, and thus "reads himself in." The next day is occupied, from eleven to four o'clock, with papers and the discussions they originate; and in the evening the members dine together. The third day is also devoted to papers, and the meeting closes about five o'clock.

During the first five years the papers were disposed of in one day, but since 1866 they have been so numerous as to furnish full employment for the second day, and it is now understood that the meeting will last three days.

During the nine years a total of 152 papers have been read, which may be classified thus:—

Geology and Palæontology ..	40	Literature	4
Archæology and History ..	35	Architecture	2
Botany and Zoology	23	Art	2
Meteorology	13	Engineering	2
Economic Science	12	Mental Philosophy	2
Physics	10	Biography	1
Education	6		

The Association claims "the right, at its discretion, of printing *in extenso* in its 'Transactions' all papers read at the annual meeting," and this right has been exercised ever since the first year, when abstracts only of the papers were printed. The copyright of the papers, however, remains the property of the authors.

One of the laws provides that the Association shall, within three months after each annual meeting, publish its 'Transactions,' including the Rules, a Financial Statement, a List of the Members, Obituary Notices of all Members who have died during the year, the Report of the Council, the President's Address, and such papers, in abstract or *in extenso*, read at the annual meeting, as shall be decided by the Council. The annual volumes are accordingly in the hands of the members within the stipulated time.

The 'Transactions' for the first year was a pamphlet of fifty-four pages, whilst that for 1869—the last which has yet been

printed—was a portly octavo volume of 537 pages. Up to this time the annual issues form three goodly volumes; and the first part of the fourth volume, or the fourth volume complete, according to the quantity of matter, will be printed before the end of October. They contain a vast amount of information respecting the county of Devon, together with matter of a more general nature.

Every author receives gratuitously twenty-five reprints of his paper, and may arrange with the printer for any greater number.

The next annual meeting will be held at Bideford, commencing August 2nd, 1871, when the Rev. Canon Kingsley will be the President.

The inhabitants of the towns in which the meetings have been held have always given the Association a cordial welcome. A large amount of both public and private hospitality has been displayed, a conversazione has commonly occupied one of the evenings, and the day after the close of the meeting has usually been spent in some picnic or fête.

It may be stated, in conclusion, that the Devonshire Association originated with men who were and still are members of the British Association, and whose active work for the offspring has not caused them to work a whit the less for the parent.

NOTICES OF SCIENTIFIC WORKS.

Researches on Diamagnetism and Magne-crystallic Action, including the Question of Diamagnetic Polarity. By JOHN TYNDALL, LL.D., F.R.S., Professor of Natural Philosophy in the Royal Institution. London: Longmans, 1870.

THIS work is the first instalment of a complete collection of the original memoirs on experimental physics, which the learned author has published during the last eighteen years. It contains not only a record of his own work on the subject of diamagnetism, but also extracts from the writings of Faraday, Plucker, Becquerel, Matteucci, Weber, and other experimental philosophers, bearing upon the same phenomena, so that the reader has before him everything necessary for a complete understanding of this very intricate subject. The second part of the book contains letters, essays, and reviews, relating to magnetism and electricity, and includes among others a discussion on the existence of a magnetic medium in space, the relation between magnetism and the electric current, an account of the polymagnet, and one of the clearest descriptions of Ohm's theory which we have ever read.

We are so accustomed to see a magnetic substance like iron or a magnetic needle point north and south, rush to the poles of a magnet when brought near to one, or arrange itself axially when suspended between the poles, that it is difficult to imagine that the vast majority of substances possess almost diametrically opposite qualities. When brought near to a magnet of sufficient power they are repelled from it, and when suspended freely between its poles they swing round, if of an elongated form, and arrange themselves equatorially or at right angles to the line joining the two poles, apparently with the object of getting as far away from them as possible. This action was named by Faraday "*Diamagnetism*," the common phenomena exhibited by iron being named "*Paramagnetism*," whilst *Magnetism* is used as a general term to include the whole range of both phenomena. Paramagnetic bodies are few in number, but they include some of extraordinary energy, iron, nickel, cobalt, and oxygen for instance; whilst diamagnetic bodies include the greater number of the metals, and such substances as rock crystal, heavy spar, sulphate of magnesia, marble, alum, common salt, saltpetre, carbonate of soda, Iceland spar, tartaric acid, citric acid, water, alcohol, ether, the mineral acids, glass, iodine, phosphorus, sulphur, resin, spermaceti, sealing-wax, turpentine, india-rubber, sugar, starch, gum arabic, wood, fresh beef, blood, apple, bread, &c. In fact, could a marble statue, or its living prototype,

be suspended between the poles of a sufficiently powerful magnet it would set equatorially, or east and west instead of north and south. Of all diamagnetic bodies bismuth has attracted the most attention, owing to the comparative power which it exhibits. Its diamagnetic properties, although vastly inferior to the paramagnetism of iron, are yet sufficiently marked to enable its properties to be observed with small permanent magnets weighing a few ounces; whilst a bismuth needle freely suspended will set itself parallel to the wires of a galvanometer. The property is not one possessed permanently by the bismuth, but is simply induced by the proximity of the magnet, nothing being communicated which the bismuth can carry away.

Having shown almost complete antithesis between the magnetism of iron and bismuth, the question naturally arose, Is this extended to polarity? Faraday worked long and earnestly at this question, and we believe to the last he was not satisfied that the question of polarity in diamagnetic bodies was settled, although the experiments with Weber's exquisitely beautiful apparatus were tried in his presence by Professor Tyndall. In a letter to Matteucci, dated November 2, 1855, Faraday wrote, "All Tyndall's results are to me simple consequences of the tendency of paramagnetic bodies to go from weaker to stronger places of action, and of diamagnetic bodies to go from stronger to weaker places of action, combined with the true polarity or direction of the lines of force in the places of action." On the other hand, it would appear as if these two philosophers were looking at the subject from entirely different points of view. Faraday had his mind fixed on lines of magnetic force, the use of which, as true representations of nature, he said never failed him; whilst Tyndall limited his view to that doubleness of action in which the term polarity originated. But these were apparent differences only, not differences in reality, for in the letter just quoted, Faraday said, "I differ from Tyndall a good deal in phrases, but when I talk with him I do not find that we differ in facts. That phrase polarity in its present undefined state is a great mystifier."

Considerable space is given to the description of the beautiful instrument devised by M. Weber in order to submit this question to a crucial test, the design of which was ably carried out by M. Leyser, of Leipzig. Clear engravings of it are given, and the experiments are described in full detail. With it not only has diamagnetic polarity been proved to exist in the case of bismuth, but the same result was obtained with cylinders of calcareous spar, statuary marble, phosphorus, sulphur, heavy glass, distilled water, bisulphide of carbon, and other non-conductors of electricity, removing the scruples of those who saw in the first experiments of this sort an action produced by induced currents. By these experiments,

Professor Tyndall concludes that a body of evidence has accumulated in favour of diamagnetic polarity, which places it among the most firmly-established truths of science.

This being the case, it would be of interest to ascertain on which side exists the fallacy of reasoning by which Professor Thompson has reduced the existence of diamagnetic polarity to an apparent absurdity; the paradox is well stated in the following quotation from a paper by Faraday, "On some Points of Magnetic Philosophy," published in the 'Philosophical Magazine' for February, 1855:—"If a globe of bismuth be placed without friction in the middle of the magnetic field, it will not point or move because of its shape; but if it have reverse polarity, it will be in a state of unstable equilibrium; and if time be an element, then the ball, being once moved on its axis ever so little, would then have its polarity inclined to the magnetic axis, and would go on revolving for ever, producing a perpetual motion. I do not see how this consequence can be avoided, and therefore cannot admit the principles on which it rests. The idea of a perpetual motion produced by static forces is philosophically illogical and impossible, and so I think is the polarity opposed or adverse static condition to which I have already referred."

Of course if time does not enter as an element in diamagnetic induction the above argument falls to the ground; but it appears to be so firmly established a fact that an exertion of physical force occupies *time*, that it can scarcely be doubted that it is concerned here also; that was Faraday's opinion, although he admitted that it seemed to be so brief in period as to be inappreciable by the means he had employed.

We should have liked to give an extended notice of the second subject included in the title of this work, namely, Magne-crystallic action,—the phenomena of which were at first so paradoxical as to baffle the ingenuity of the most acute experimentalists, but, thanks to the labour of Professor Tyndall and other physicists, now deducible with as much care and certainty from the action of polar forces as the precession of the equinoxes is from the force of gravitation. In the author's language, "The whole domain of magne-crystallic action is thus transferred from a region of mechanical enigmas to one in which our knowledge is as clear and sure as it is regarding the most elementary phenomena of magnetic action."

The magne-crystallic force is one by which certain crystals are caused to set themselves with certain of their axes parallel or transverse to the lines of magnetic force acting on them. This force acts at a distance, and is by no means so weak as might be at first supposed, for just as a crystal is moved by the magnet at a distance, so can the crystal also move the magnet at a distance. Faraday obtained the latter result by converting a steel bodkin into a magnet

and suspending it freely in the neighbourhood of the crystal. The tendency of the needle was always to place itself parallel to the magne-crystallic axis.

Neither will space permit us to refer, except in the briefest manner, to the results obtained by preparing bars of magnetic and diamagnetic substances, by reducing them to fine powder, and then compressing them in moulds in such a manner that the line of greatest compression is in different directions along or across the bar. A bismuth bar so prepared, squeezed flat within the jaws of a vice and suspended between the poles, will turn with the energy of a magnetic substance into the axial position; whilst a bar made up of powdered carbonate of iron (magnetic) compressed in this manner will recoil from the poles as if violently repelled. It thus appears that the line of magnetic action has a near relation to that of the closest contact among the material particles, and this relationship is traced in many different ways, and appears related to the cleavage of crystals.

It would be of interest to try some of these experiments on diamagnetism with the metal Thallium, a metal which, whilst it rivals, if it does not surpass, bismuth in diamagnetic energy, is as soft and amorphous as lead, and lends itself with the same facility to moulding and compression. Probably many of the apparent anomalies of diamagnetism which observers at first encounter, owing to the highly crystalline nature of bismuth, would disappear if thallium were the metal selected for experiment.

We cannot close this book without expressing the profound admiration which it leaves in the mind for the author's philosophical acumen and experimental skill. He moreover possesses one valuable quality, which we regret to say is as rare amongst scientific men as the combination of the two former,—that of placing his views and describing his experiments in such clear language that the profoundest mysteries of nature seem under his treatment to become clear and simple to a child's comprehension. Speaking as one who never loses an opportunity of listening to this philosopher on whom the mantle of Faraday has so worthily descended, the writer scarcely knows which gives him greater pleasure—to listen to one of Dr. Tyndall's lucid expositions of some hitherto hidden mystery of nature, or to hear him in his clear logical manner quietly put down a scientific opponent who has ventured to differ from some of his conclusions.

ON SAVAGES.*

What Sir Charles Lyell has accomplished for the student of Geology, Sir John Lubbock is now achieving for the student of Ethnology. His 'Pre-historic Times'† first excited and awakened public attention by the clearness of its descriptions and the able and masterly manner in which the author dealt with the questions relating to primitive man.

In the present work Sir John Lubbock has adopted the same inductive method of reasoning which has been so ably applied to geological investigations by the illustrious Lyell in his 'Principles,' *viz.* that of explaining the monuments of the earth's past history by the "living present." Thus, from the habits and customs of modern savages we are enabled to understand the meaning and uses of the various relics of early man met with in civilized countries where no primitive races now exist, and we can thus more accurately picture and more vividly conceive the manners and customs of our ancestors in bygone ages.

Founded upon a course of lectures, originally delivered at the Royal Institution in 1868, the author proposes in the present volume "more particularly to describe the social and mental condition of savages, their art, their systems of marriage and of relationship, their religions, language, moral character, and laws." Sir John promises in a future volume to publish those portions of his lectures which have reference to their houses, dress, boats, arms, implements, &c.

"The study of the lower races of man," writes the author, "apart from the direct importance which it possesses in an empire like ours, is of great interest from three points of view. In the first place, the condition and habits of existing savages resemble in many ways, though not in all, those of our own ancestors in a period now long gone by; in the second, they illustrate much of what is passing among ourselves, many customs which have evidently no relation to present circumstances, and even some ideas which are rooted in our minds, as fossils are imbedded in the soil; and thirdly, we can even, by means of them, penetrate some of that mist which separates the present from the future."

On the subject of savage intellect, it seems difficult to realize the extreme mental inferiority of the lower aborigines; the mind of the savage, like that of the child, is of wonderfully small capacity and limited in its powers of taking in ideas; it is easily fatigued by exercise, and is generally in a dormant state. Curious instances

* 'The Origin of Civilization, and the Primitive Condition of Man' (Mental and Social Condition of Savages). By Sir John Lubbock, Bart., M.P., F.R.S., &c. 8vo. Pp. 380. London, 1870. Longmans and Co.

† Originally published (in part) in the 'Natural History Review.'

of this are mentioned from the accounts of various travellers; indeed, the number of authorities quoted under each chapter is truly surprising. No fewer than 178 authors and upwards of 200 works have been consulted and are referred to in these pages, the author in every case being cited, and credited with the statement made on his authority.

The cosmopolitan character of some customs has induced a strong belief in the unity of origin of the races among which such practices prevail; for example, among many races a woman is absolutely forbidden to speak to her son-in-law. Another curious custom is that known in Bearn under the name of "La Couvade." It would seem to be a very wide-spread custom for the father, upon the birth of a child, to be put to bed instead of the mother. The ideas among savages respecting the influence of food are equally ludicrous. Thus the Malays give a large price for the flesh of the tiger, not because they like it, but because they believe that the man who eats tiger acquires the sagacity as well as the courage of that animal. For the same reason the New Zealand baby at its baptism is made to swallow pebbles, so that its heart might be hard and incapable of pity. The reflexion of many of these ideas still linger with children and uneducated persons. A little girl was heard to say to her brother, "If you eat so much goose you will be quite silly." To take the portrait of a native is looked upon as most injurious, and the better the portrait the worse for the sitter; so much life could not be put into the copy except at the expense of the original. Pictures are also considered as efficient charms. Writing is believed to be even more magical than drawing.

Mungo Park on one occasion profited by this idea; a Bambarran offered him a supper of rice if he would write him a charm on his writing-board, to protect him from wicked men. The proposal was at once accepted. Park wrote the board full from top to bottom on both sides. The Bambarran, in order to secure the full force of the charm, washed the writing from the board into a calabash with a little water, and having said a few prayers over it, drank the powerful draught; after which, lest a single word should escape, he licked the board until it was quite dry.

The science of medicine, indeed, like that of astronomy, and like religion, takes among savages very much the character of witchcraft. Many savages do not believe in disease or natural death, but if a man die, however old, they conclude that he must have been the victim of magic.

Twins are considered as a bad omen, and in most cases one, in some others both are killed.

The belief in the attributes of life appertaining to inanimate objects is also very wide-spread.

A hook that has once caught a big fish is preferred to twenty

that have never been tried. Two fish-nets are never put together, for fear they should be jealous. The story of the natives of Tahiti who sowed some iron nails given them by Captain Cook, hoping thus to obtain young ones, reminds the writer of the story of a little boy of his own family, who planted his hair in his garden expecting it would bring forth a crop of little boys like himself. The ability or inability to draw seems to vary in one and the same tribe of aborigines; the absence of perspective is also very general, and extends to many people otherwise in a highly advanced state of civilization, such as the Egyptians, Assyrians, and the modern Chinese.

The earliest traces of art yet discovered belong to the Stone age—to a time so early that the Reindeer was abundant in the south of France, and that probably, though on this point there is some doubt, even the Mammoth had not entirely disappeared. These works of art are sometimes sculptures, if one may say so, and sometimes drawings or etchings made on bone or horn with the point of a flint.

The Esquimaux etchings of the present day appear to approach most nearly to these early relics from the caves of France, but they lack the spirited style of execution of the latter.

Upon the marriage rites, if such they may be called, much information is collected, but, as the author truly observes, many of the facts which he has recorded are very repugnant to our feelings, although it was impossible not to mention them in such a work. Marriage by capture appears to be very general all over the world, and where not attended by real violence the pretence of using force and even blows is kept up in form. The practice of carrying off the bride to the woods may yet linger among civilized nations, as, for example, in our own custom of the wedding tour.

The position of women among savage nations generally is very deplorable, nor can any amount of romance render savage life otherwise than revolting to an educated and civilized man.

Notwithstanding our advanced state of civilization, it is impossible, however, to deny the fact that—

"In many of our ideas and tastes we are still influenced by the condition of our ancestors in bygone ages."

"What that condition was," says the author, "I have in this work endeavoured to indicate, believing as I do that the earlier mental stages through which the human race has passed are illustrated by the condition of existing or recent savages. The history of the human race has, I feel satisfied, on the whole been one of progress. I do not of course mean to say that every race is necessarily advancing: on the contrary, most of the lower ones are almost stationary; and there are, no doubt, cases in which nations have fallen back; but it seems an almost invariable rule that such

races are dying out, while those that are stationary in condition are stationary in numbers also; on the other hand, improving nations increase in numbers, so that they always encroach on less progressive races."

It would be impossible in this brief notice to convey a very adequate idea to the reader of the mass of well-arranged facts upon which Sir John Lubbock has established his conclusions, but we give them in his own words.

"The facts and arguments mentioned in this work afford, I think, strong grounds for the following conclusions, *viz.*:—

"That existing savages are not the descendants of civilized ancestors;

"That the primitive condition of man was one of utter barbarism;

"That from this condition several races have independently raised themselves."

Sir John Lubbock thinks we shall not be the less inclined to adopt these conclusions on account of the cheering prospects which they hold out for the future.

We heartily thank the author for his interesting book, which has afforded us not only much instruction, but also much real amusement in its perusal.

THE SCIENCE OF BUILDING.*

The science of building is so comprehensive, and has been treated by so many able writers, that we must be prepared for some disappointment when perusing a work whose title would lead us to believe that the whole subject is included in its pages.

Since the application of iron to building purposes, a new study has presented itself to the architect, and Mr. Tarn's book contains many formulæ with which those who belong to his profession would do well to make themselves acquainted; for it is not uncommon to find such errors committed by them, as the loading of cast-iron girders to their full breaking weight, or a waste of metal in making them stronger than is necessary.

Whilst we commend the work to persons entering the building trade, we consider it right to mention that the study of mechanics, such as may be followed with the aid of 'Tate's Exercises in Mechanics,' would be even more useful to builders than Mr. Tarn's book, as it would sooner make them acquainted with the elements

* 'The Science of Building: an Elementary Treatise on the Principles of Construction.' By E. Wyndham Tarn, M.A., Land Architect. Lockwood and Co.

of mechanics which are indispensable to all who follow the profession.

In the chapter on retaining walls, the author should have directed the student's attention to the various methods of constructing them, and should have explained the difference between a vertical wall having its beds horizontal or perpendicular to its face, and one with an inclined face, and the transverse section of joint, perpendicular to that face. Also, in a brick retaining wall some advantage would be derived from the disposal of the length of brick or style of bond, and to the architectural student those are matters of great importance, for in many cases practice seems to defy theory. The author does not extend his chapters to the relative strength of brickwork, nor to an account of the various kinds of bricks made throughout England; details which are now essential in such a work, as bricks rank in these days amongst the most important materials of construction. His chapter on arches might also with advantage have been extended to the flat soffit and head or cambre arch, showing the limit of span for a given depth and breadth of face and soffit; also to observations on the groin arch, which would have imparted originality to his work.

The remarks on mortar and cement are limited, and it would have been well to refer to their tenacity and resistance to compression, their suitability for various situations; and the advantage of the application of concrete to bad foundations.

The information on centering of arches is also too much restricted and too indefinite. The pressure of the voussöirs in a pointed arch could not act on the centre at any of the angles in the manner named by the author, and it would have been better had he named the description of arch to which his remarks have reference, as the pressure of the voussöirs differs considerably in elliptic, pointed, and semi- or segmented arches.

The chapter on iron does not refer to the segmental or curved girder which is applied with much advantage in engineering, in railway and other works. There is also room in the chapter for observations on the trussed girder and the advantage or disadvantage of applying wrought-iron fitch-plates to wood beams. All these matters should have been referred to, so that the student of the 'Science of Building' (a title by the way which is likely to mislead those who purchase it into the belief that it is an advanced treatise) might be prevented from committing many errors into which architects and builders are too prone to fall.

CHRONICLES OF SCIENCE,

Including the Proceedings of Learned Societies at Home and Abroad; and Notices of Recent Scientific Literature.

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1. AGRICULTURE.

The drought of 1870, though not so utterly destructive of succulent growth during the summer season as that of 1868, has been more injurious on the whole. Beginning earlier and ending later, it has spoiled both the hay crop and the aftermath; and the wheat crop too, generally so able to withstand a dry summer, has materially suffered. The returns from the correspondents of the 'Agricultural Gazette' declare the wheat crop to be below an average; and all other grain crops, except barley throughout Scotland, and perhaps the pea crop throughout the country generally, are still more below an average. Neither in its return of food for man nor in its promise of food for beast, does the harvest of 1870 compare favourably with its predecessors. Mr. Lawes, of Rothamsted, who has for twenty-seven years subjected the wheat crop to specific treatment of many different kinds, reports upon the other hand his produce to be this year above the average. There has been, he says, a splendid seed-forming and seed-maturing season, acting however in many cases upon an insufficient amount of plants, and it is probable therefore that some of the heaviest and some of the lightest crops ever known in England have been grown this year.

Among the leading agricultural events of the past quarter are the great annual meetings of the Royal Agricultural Societies of the three kingdoms. The English Agricultural Society at Oxford and the Highland Society at Dumfries have had capital meetings. The Irish Agricultural Society was less successful. One of the most interesting circumstances of the Oxford meeting was the award of a valuable prize to the best-managed farm of the district. It has been somewhat of a surprise and perhaps a disappointment to the agricultural optimists of the day, that the very competent jury appointed by the Society to examine the competing farms should have placed highest upon the list one which owes but little to the improved stock and implements whose use and introduction the Society has fostered. It is a somewhat old-fashioned style of management which has been thus decorated. The four-course rotation of wheat, turnips, barley, and clover in succession is the cropping of the farm; the live stock is inferior, and comparatively few modern implements are in use. The visitor who in the morning

left the showyard of the Society full of the best specimens of the finest breeds of all kinds of farm stock and every new agricultural machine, saw nothing of either on the "best-managed farm" which he walked over in the afternoon. He saw, however, magnificent crops of grain, and roots, and grass, obtained without their aid, and he might conclude that what was wanted for the improvement of English agriculture was not a Society stimulating the production of the best machines and live stock, but an agency for making farmers more energetic and laborious in the use of the common means already everywhere at their command.

This agency it is plain exists in an improved relationship between the landlord and the tenant. The nature of the best farm agreement has been the subject latterly of frequent discussion in the agricultural journals. The lease for a term of years, with freedom to cultivate the land as the tenant chooses up till within a few years of the close of the term, is certainly the system which gives freest scope to the intelligence and energy of the tenant, and most likely therefore to result in industrious and successful cultivation.

An interesting paper "On Wheat Flies" appears in the 'Agricultural Gazette,' from which we learn that *Cecidomyia tritici*, to which Professor Henslow drew attention thirty years ago as the most destructive wheat midge of his time, is no longer prevalent; and that the complaints now common of injury from the wheat midge are due to *Lasiopteryx obfuscata*. The former is a yellow fly, the latter black. The insect is not easily bred, neither Mr. Kirby, Mr. Curtis, nor Professor Henslow having succeeded. The successes of Miss Eleanor Ormerod, of Sedbury Park, Chepstow, which are recorded in the 'Agricultural Gazette,' seem to have been wholesale, notwithstanding her failures in detail. She placed on earth in different flower-pots, grubs and pupæ, with the ears and stalks to which they respectively adhered, as well from wheat as barley, protecting each with a covering of gauze or muslin. These were kept in the most natural conditions, and carefully watched and tended all through the winter and spring, without producing anything; but a small heap of wheat rubbish, which had been ascertained to be well supplied with grubs and pupæ, was left in an out-of-the-way corner by itself, and early in June was found to be swarming with a cloud of these small Cecidomyia-looking midges, *viz. Lasiopteryx*. "Numbers of these," says the writer whom we are quoting, "were also obtained, and sent to us from the wheat fields at different dates, but not a single specimen of the *Cecidomyia tritici* reached us. Now, is this abundance of *Lasiopteryx* and scarcity of *Cecidomyia* confined to the neighbourhood of Chepstow, or is it general over the whole country? If so, another question, which however, we can scarcely hope to fathom, is—when *Cecidomyia* ceased to be prevalent, and *Lasiopteryx* took its place. It may

even be a question whether *Cecidomyia* ever was generally prevalent—it may have been so only in KIRBY's time and the London district."

The Rivers Pollution Commissioners have issued a report upon the so-called "A B C" process for defecating sewage. They pronounce it a failure. The sewage treated on this plan is not defecated, and the manure produced is extremely poor. The only advantage derived from its adoption is a somewhat quickened subsidence of the suspended matters which town sewage carries with it, but as every 10 cwt. of these are rattled through the sewers of a town, borne along in the case of a town with ordinary water supply in a thousand tons of water, it is not likely that these suspended matters can retain much that is soluble or valuable on their exit from the sewer system of a town. And in point of fact the solid matters of town sewage are of very little agricultural value indeed. It is the liquid portion that contains the elements of the food of plants; and it is this, therefore, in which these substances are present in too dilute a form to be precipitated that must be carried to the land, if either a nuisance is to be abated or a valuable property to be turned to good account. The Commissioners pronounce sewage irrigation to be the only method known to them by which both these results can be attained.

There has been an unusual prevalence of cattle disease during the past quarter. During the severely restrictive system under which alone cattle traffic was permitted during the prevalence of the cattle plague, the more common diseases, the foot-and-mouth affection and pleuro-pneumonia, almost disappeared. They have resumed their frequency and virulence with the relaxation of the rules affecting cattle-markets.

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2. ARCHÆOLOGY (PRE-HISTORIC).

*Primeval Monuments of Peru.**—Mr. E. G. Squier, the well-known American archæologist, has lately explored the early megalithic monuments of Peru. The great plateau of the Andes, elevated 13,000 feet above the sea, and fenced in with high mountains and frigid deserts, possesses nevertheless a number of stone structures belonging to what is regarded through the world as the earliest monumental period, coincident in style and character with the so-called cromlechs, dolmens, and "Sun" or "Druidical" circles of Scandinavia, the British Isles, France, and Northern and Central Asia.

Considerable importance attaches to these remains, as indicating

* By E. G. Squier, M.A., F.S.A., &c. From 'The American Naturalist,' vol. iv., 1870, p. 1.

the existence at one time in Peru of a population identical in the degree and stage of their constructive development with the people who raised corresponding lithic and megalithic structures in other parts of the world, and who, if not the progenitors of the semi-civilized nations found in Peru at the time of the conquest, certainly preceded them in the occupation of the country. Mr. Squier suggests that, "if it should be found that there has been a gradual development of any of the rude remains into elaborate and imposing monuments, corresponding with them in their purpose or design, or a gradual change from the rough burial-chamber of uncut stones into the symmetrical sepulchral tower, built of hewn blocks accurately fitted together, and in general workmanship coinciding with the other and most advanced and admirable structures of the country, then we may reasonably infer that the latter were constructed by the same people that built the first, and that, monumentally at least, the civilization of Peru was indigenous and gradually developed, and not introduced."

The first and simplest form of burial monument, and which the author assumes to be the oldest, consists of flat unhewn stones of various lengths set firmly in the ground, projecting above it from 1 to 2 feet, so as to form a circle, more or less regular, about 3 feet in diameter. In this circle, the body was buried in a crouching posture, with a vase of pottery or some other utensil or instrument at its feet. Sometimes a few flat stones were laid across the upright ones, so as to form a kind of roof. These rude tombs were sometimes placed side by side in long rows, and stones afterwards heaped over them. A more advanced form of tomb consists of large slabs of stone projecting 4 to 6 feet above ground, and set in a circle from 6 to 16 feet in diameter. The top is roofed by blocks of stone which lap over each other inwardly until they touch, forming a rude arch or vault. At Quellenata, N.E. of Lake Titicaca in Bolivia, and at many other places in the ancient Callao, these same tombs occur, but they are enclosed in a circular wall, varying from 10 to 30 feet in height, the stones broken so as to conform to the outer curve of the tower, and the whole cemented together with clay. These round *chulpas* are of varying excellence in workmanship and design, and lead up to the square *chulpas* of Escoma, the sides of which are vertical with a projecting cornice near the summit, and divided internally into two stories or chambers. At Sillustani the largest and best-built *chulpas* occur, constructed of great blocks of trachyte and other hard stones fitted together with unsurpassable accuracy, the structure nevertheless preserving some of the characteristic features of the first and rudest form of *chulpa*. The stones forming the dome are not only cut on accurate radii, but the curve of the dome is preserved in each, tending to give compactness and strength to the whole structure.

Mr. Squier also mentions that many stone structures exist in Peru, corresponding with the so-called Cyclopean monuments of Italy. He describes many sun-circles, some composed of simple upright stones, others having in addition a regular causeway of slabs, forming a platform of stone more or less hewn and fitted together.

In the ancient town of Chicuito, a singularly fine and massive rectangular monument exists, measuring 65 feet on each side. The author considers this to be the most advanced megalithic structure in Peru, and proposes in a future work to illustrate it more fully. When the whole of Mr. Squier's drawings are published, he believes all students of these archaic monuments will agree with him, that there exist in Peru and Bolivia, high up among the snowy Andes, the oldest forms of monuments, sepulchral and otherwise, known to mankind, exact counterparts in character of those of the "old world," having a common design, and all of them the work of the same peoples found in occupation of the country at the time of the conquest, their later monuments being developed forms of those by their ancestors, and the earliest the productions of primitive man in all parts of the world, and not derivative.

Mr. Squier has thus furnished another admirable illustration of the well-established law that "man under analogous circumstances will act in a similar manner irrespective of time or space."

Stone Implements from Burmah.—Mr. W. Theobald, jun., of the Indian Geological Survey, has communicated some notes on the stone implements of Burmah, to the Asiatic Society of Bengal. The implements are curious as differing in form and type, not only from anything found in India, but from anything hitherto described from any part of Europe, though any implement yet found in India has its precise analogue in Europe. These implements are not only singular in form, but also in the material out of which they are manufactured; being fashioned either of basalt or some schistose rock, quite unlike anything met with in the district where the implements occur: a fact which seems to indicate that they were brought down from Upper Burmah, where such implements are common, by the original settlers of the country. The same superstition which connects these implements with the "thunderbolt" prevails in Burmah, where they are called "mogio," or thunderbolts. Curious traditions prevail as to the virtues possessed by these heaven-born stones: such, for instance, as preserving from lightning, fire, shipwreck; conferring invulnerability upon the wearer; great medicinal virtues, a chip administered internally curing inflammation of the liver; it is also a specific for ophthalmia, &c. The types of these Burmese instruments described by Mr. Theobald are:—1. A rough, stout, wedge-shaped instrument, closely resembling the better finished specimens of flint-hatchets, of the type which occurs in the Danish kjökkenmöddings.

This form is very rare. 2. A hatchet with flat sides converging towards the base which is square, and with a segmental edge, much like the common German form. This type is common. 3. A long adze with square, slightly converging sides, and a bevelled segmental edge, in character much resembling some of the implements discovered in Java, Borneo, and Sumatra, and also a New Zealand form. 4. Implements of the same character, so far as the edge and sides are concerned, but having the butt end reduced in width so as to produce a square shoulder on each side of the blade. In some this reduction in width extends more than half the length of the blade, so as to produce a T-shaped form. These shorter specimens are the most common. This form appears to be peculiar to Burmah.

Mr. John Evans, F.R.S., F.S.A., offers some valuable critical notes upon Mr. Theobald's discovery, in 'Nature.'* He says:—

"In some cases the lashings used to fasten them to their hafts have left traces on the stone. The implements are usually picked up on the surface of the hills, and in the fields, or clearings made for cultivation, and not in the plains.

"Mr. Theobald seems inclined to doubt whether, without the use of iron also, those who made these implements could have effected clearances in the gigantic forests of Pegu; but it may be urged against this view that by calling in the aid of fire the efficiency of such tools is almost as great as if they had been formed of metal, and it is difficult to conceive a people in possession either of bronze or iron bestowing the necessary time and trouble on the fashioning of stone tools when those of metal were at their command, which, whether fire were employed in the clearance or no, were for general purposes so much more effective. If the makers of those stone tools had been in possession of other means for clearing the hill-sides, then Mr. Theobald would be inclined to regard the stone relics as agricultural implements used in hand agriculture, at the end of sticks, as a kind of spade, to form the shallow holes for the cultivation of 'hill rice.' If not explained in this manner, he argues, we must regard them as weapons of the chase and war, though this use is, he thinks, negatived by their thoroughly inefficient character for such purposes.

"To this may be objected, first, that the material of which they are usually formed is basalt, a stone constantly used as a material for cutting-tools; secondly, that the presence of the square shoulders, so like those on the horn sockets for hatchets of the Swiss Lake-dwellers, seems to testify to the tools having been used as adzes or axes, or possibly chisels; and thirdly, that if they had been required merely for hoeing or digging, the trouble of grinding and polishing might and would have been saved."

* Vol. ii., No. 32, p. 104.

*The Cheesewring threatened with Destruction.**—This very remarkable pile of rocks, six or seven miles north of Liskeard in Cornwall, is threatened with imminent destruction by quarrying operations at its foot. Will no one prevent its demolition? A committee was formed some time since for the express purpose of arresting by all possible means the Vandals who are everywhere plotting the overthrow of our ancient megalithic monuments. Surely the preservation of this fine dolmen is worth an effort.

The Meenas of Central India.—Lieut.-Colonel Showers has communicated to the Asiatic Society of Bengal an account of the Meenas, a wild tribe of Central India occupying the hilly and jungly country of Jehazpoor, where they appear to have maintained their independence and carried on a marauding life for centuries. They are described as a fine race of men, endowed with great personal courage, and addicted to the use of arms. They marry freely with other tribes, but never allow their daughters to marry out of their own tribe. Polygamy is allowed, each man having three or four wives. The aggregate male adults in the tribe is about 24,000.

Roman London.—Numerous remains of oxen and horned sheep were found some few years since on the site of old London Wall, near Moorgate Street. They had been all killed with the blow of a blunt instrument on the forehead, probably a stone celt. From associated relics there can be little doubt that this was one of the slaughtering places of the ancient inhabitants of London in Roman times. The Wall-brook evidently ran here, as the foundations of the old wall was built on piles. Another and recent excavation repeats the same story, and shows an old river-bed of silt, with numerous bones of animals.

Ethnological Society.

At the Ethnological Society papers have been read during the past quarter by Mr. C. Spence Bate, F.R.S., "On the Pre-historic Monuments of Dartmoor." Mr. Bate gives a melancholy account of the wanton destruction of the cromlechs in this district, and suggests obtaining legal protection for them before they are all demolished.

Dr. Caulfield records the discovery of copper celts near Buttevant, Co. Cork, and describes a supposed Ogham inscription from Rusglass, Co. Cork.

Lieutenant S. P. Oliver reports the recent destruction of another cromlech in Jersey.

Professor Huxley gave an interesting account of "the chief modifications of mankind, and their geographical distribution."

* 'Nature,' vol. ii., p. 101.

The characters of greatest value are—colour, character of hair, and form of the skull. The author described five distinct types. 1. The Australioid. 2. The Negroid. 3. The Xanthochroic, with fair skin and blue eyes. 4. The Melanchroic, a type with dark complexion, occupying an area between the Xanthochroic and Australioid peoples; and 5. The Mongoloid. The paper was illustrated by a large coloured map showing the distribution of these five groups and their subdivisions.

Professor Busk described the opening of the Park Cwm Tumulus in the peninsula of Gower, South Wales.

The Rev. Canon Greenwell read a paper "On his Exploration of Grimes's Grave, Norfolk" (see last Chronicle, p. 383).

Mr. Boyd-Dawkins gave an account of some remains of Platycnemic or Flat-shinned people in Denbighshire. The remains were found in two bone-caverns, a refuse-heap, and in a tumulus. Similarly-formed bones have been obtained from Cro-Magnon Cave in France, and the caves of Gibraltar.

Colonel Lane Fox described the Dorchester dykes and Sinodun Hill, and showed the works were British, and not Roman.

Mr. David Forbes, F.R.S., described the Aymara Indians of Bolivia and Peru. In stature they are small, massive, and thick-set, with large heads and short limbs. The trunk is disproportionately large, and the capacity of the thorax enormous, being adapted to meet the requirements of respiration at an altitude of 8000 to 16,000 feet above the sea-level, where the atmosphere is proportionately rarified. Many interesting customs, &c., relative to this people were recorded by the author.

Anthropological Society.

Dr. Hudson read a paper "On the Irish Celt;" Mr. G. H. Kinahan "On the Race Elements of the Irish People;" and Dr. Beddoe "On the Kelts in Ireland." Dr. Beddoe describes the Irish as a dark-haired but light-eyed race, and he argues that wherever there is light hair it may be accounted for by the Danish or English intercrossing. The dark hair of the Irish may be, partly at least, attributed to the Gaelic Kelts.

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3. ASTRONOMY.

(Including Proceedings of the Astronomical Society.)

As we write, the prospects of the eclipse expeditions hardly appear so favourable as could be wished. It seems doubtful whether Government will be willing to aid the expeditions by supplying the

means of transport,—the reason suggested for the expected refusal being the war which is at present devastating France. We can scarcely believe, however, that the Government will abide by this resolution. Remembering that some of the most important of those researches which adorn the annals of English science have been prosecuted under Government protection, and with Government aid, while England has been in the throes of deadly warfare—nay, when the very existence of England has been at stake—we refuse to believe that the mere risk of war should cause our Government to refuse a single ship in aid of scientific observations of extreme interest and importance.

Unfortunately, the mere report of such a probability has sufficed to check the process of preparation; and despite our confidence that England is not destined to suffer shame in this matter, we are compelled to recognize the possibility that the only systematic observations of this important eclipse will be made by French astronomers in Algeria.

Further on will be found an account of the extent to which the eclipse will be partially visible in this country.

Dr. Zöllner, known as one of the most successful students of solar physics, has been inquiring into the evidence which the form and dimensions of prominences afford respecting the temperature and physical condition of the sun. He points out that prominences may be divided into two classes, the cloud-formed and the eruptive prominences. Those belonging to the latter class are so obviously due to real eruptive action that we may fairly refer them to the same general cause as terrestrial eruptions, that is, to a difference between the pressure in the region whence the erupted matter flows and the pressure in the space into which that matter passes. But this view requires us to believe that there is a barrier-layer (*Trennungschicht*) by which one region is separated from the other—a stratum limiting the compressed hydrogen below the chromosphere from the free atmosphere of hydrogen which constitutes a proportion of that envelope.

Starting with this hypothesis, Dr. Zöllner proceeds to apply the mechanical theory of heat to determine the temperature of different portions of the sun's globe. We see that the prominences are projected to a certain height, and we have therefore a means of determining the force exerted in the propulsion of the compressed hydrogen. The equations for this purpose are those resulting from the law of Mariotte and Gay-Lussac, and those which are deduced from the theory of heat. Certain assumptions have to be made, the probability of whose truth depends on the interpretation of telescopic and spectroscopic observations of the sun.

Some of the results are of great interest, especially as, even though the fundamental suppositions should be importantly in error,

the conclusions would still be but slightly affected. Zöllner finds the minimum temperature of the base of the solar atmosphere to be about 27,700° Centigrade, and the corresponding temperature in the region whence the prominences are projected to be about 68,400° Cent. He calculates the pressure in this last-named region at 4,070,000 atmospheres, while the pressure outside the stratum enclosing this region he calculates at 184,000 atmospheres. He then shows that whereas these results have been obtained on the supposition that the pressure at the base of the chromosphere is but that corresponding to about 7 inches (180 mm.) of the mercurial barometer, the actual pressure of the nitrogen and oxygen atmospheres at this level must be almost infinitely minute. But he remarks that this alone does not suffice to explain the absence of the lines of these elements from the spectrum of the sun, since the lines of volatilized metals are seen. He attributes the visibility of the latter lines to the fact that the vapours of the metallic and alkaline elements have a much greater emissive power, and consequently a much greater absorptive power than those of the permanent gases.

To proceed further with the discussion of his researches would bring us upon ground altogether removed from astronomy. We may remark, however, that there is one point which seems to us to have been too little considered in these and similar researches. It is assumed that spectroscopic researches enable us to determine the actual pressure at the base of the chromosphere. As a matter of fact, we have no means of knowing whether the estimated pressure belongs to the base of the chromosphere or to a height of ten, a hundred, or even a thousand miles above the solar photosphere. It must be remembered that 1000 miles at the sun's distance subtends little more than two seconds of arc, the minuteness of which distance will be appreciated by those who have examined double stars two or three seconds apart, even with very powerful telescopes. Assuming that with the magnifying power employed (magnifying power being an essential element in such applications of the spectroscope as we are here considering) an arc of two seconds could be recognized, yet the tenth part of such an arc would be wholly inappreciable. Now the increase of pressure within a distance of 100 miles from the base of the chromosphere is probably more considerable than that occurring throughout all the thousands of miles of chromospheric height above that level.

The most important astronomical event of the next quarter is undoubtedly the great eclipse of December 22nd next. In England it will be considerable though not total. The following are the data for the principal places in the British Isles:—

At Greenwich the eclipse will begin at 11 h. 8 m. A.M., reach its greatest phase at 12 h. 25 m. (when 0·814 of the sun's disc will be concealed by the moon), and end at 1 h. 42 m. P.M.

At Cambridge the eclipse will begin at 11 h. 9 m. A.M. (mean time at Cambridge), reach its greatest phase at 12 h. 26 m. (when 0·808 of the sun's disc will be concealed), and end at 1 h. 42 m. P.M.

At Oxford the eclipse will begin at 11 h. 1 m. A.M. (mean time at Oxford), reach its greatest phase at 12 h. 18 m. (when 0·813 of the sun's disc will be concealed), and end at 1 h. 35 m. P.M.

At Liverpool the eclipse will begin at 10 h. 52 m. A.M. (mean time at Liverpool), reach its greatest phase at 12 h. 8 m. (when 0·804 of the sun's disc will be eclipsed), and end at 1 h. 24 m. P.M.

At Edinburgh the eclipse will begin at 10 h. 53 m. A.M. (mean time at Edinburgh), reach its greatest phase at 12 h. 7 m. (when 0·788 of the sun's disc will be concealed by the moon), and end at 1 h. 21 m. P.M.

Lastly, at Dublin the eclipse will begin at 10 h. 34 m. A.M. (Dublin mean time), reach its greatest phase at 11 h. 50 m. A.M. (when 0·812 of the sun's disc will be eclipsed), and end at 1 h. 6 m. P.M.

We may remind our readers that on the 12th, 13th, and 14th of November, shooting stars may be looked for. A year or two back it was possible to indicate somewhat more definitely the time when the display was to be expected; but it needs only a careful study of the phenomena presented by the successive showers, since the great one of 1866, to prove that the meteor-system has been widening out, growing in the meantime less and less rich: so that while we may be tolerably certain of seeing many November meteors, there is small chance of a display resembling that of the year 1866.

The planet Jupiter will be well situated for observation during the next quarter, coming to opposition on December 13th. Saturn on the contrary is passing away from our nocturnal skies, and will be in conjunction with the sun on December 22nd. Mars is returning, but only at the end of the year will he be near enough to be worth studying telescopically. He comes into opposition on March 19th, 1871.

Proceedings of the Astronomical Society.

Lieut. Brown supplies an important paper on December weather in the neighbourhood of Gibraltar. It appears from the meteorological observations he records that there is every reason to anticipate favourable weather during the eclipse of December 22nd next. From the 15th to the 31st December there were in 1860, 6 very good days; in 1861, 3; in 1862, 10; in 1863, 13; in 1864, 5; in 1865, 12; in 1866, 6; in 1867, 8; in 1868, 11; and in 1869, 7; —the bad days in those years numbered, respectively, 5, 9, 1, 1, 2, ½, 2, 3, 1, 1. So that in all there were 81 good days and but 25½ bad ones, the remaining 64½ being indifferent.

Commander Ashe endeavours to show that the Council of the Astronomical Society were not justified in expressing the opinion that "in photographs 3 and 4" (of his set of 4, illustrating the American eclipse) "there is evidence of the disturbance of the telescope during the exposure of the sensitive plate. But there seems every reason to accept the opinion of the very able committee appointed by the Council to consider the matter, and the members of this committee "unanimously report that in their opinion there was a decided movement of the instrument at the time the photograph was taken; a conclusion arrived at from an examination of the chromosphere close to the moon's limb, as well as from an examination of the prominences."

In a description of the occultation of Saturn by the moon on April 19, 1870, Captain Noble dwells on the exceeding sharpness of Saturn's definition; the most delicate details being perceptible, even in contact with the moon's limb. The crape ring C was seen most perfectly where the dark limb of the moon crossed it. "I never was more impressed," remarks this skilful observer, "with the absolute absence of a lunar atmosphere of any appreciable density than I was on this occasion."

Mr. Penrose, from observation of the star Algol, concludes that the period of 2·86727 days assigned to this remarkable variable in Herschel's 'Outlines of Astronomy' requires to be slightly corrected. The minima occurred nearly three hours earlier than the epochs calculated with the above period from a minimum which occurred on January 3, 1844. The shortening of the period of this variable is certainly a remarkable and interesting circumstance. Observers should watch from time to time the occurrence of the well-marked minimum, in order to see whether the reduction of the period is steadily progressing, or to detect signs of its being eventually transmitted into the reverse process, as in the case of planetary perturbations.

Mr. Proctor, in a paper "On the Resolvability of Star-groups regarded as a Test of Distance," points out that there is good reason for doubting whether we can form any opinion whatever respecting the distance of a cluster of stars from the telescopic power necessary to completely resolve it. He shows that a star-group may be so constituted that let its distance be ever so great it cannot appear nebulous, or again that conceiving its distance to be increased so that it passed eventually beyond the range of our most powerful telescopes, it would pass from irresolvability to resolvability and again to irresolvability through the mere effect of a continually increasing distance. The question of the resolvability of a star-group depends not on distance alone, but on the relation between the magnitudes of the component stars and the distances separating them. If the magnitudes are such that the stars would vanish in-

dividually through increase of distance, before their distances from each other became evanescent, the group (or the special order of stars considered—as the case may be) could not possibly present a nebulous appearance, at any stage of its recession, with whatever telescopic power it was studied. On the other hand, if the distances between the stars became evanescent before the stars vanished individually, the group or order of stars must necessarily become nebulous when it reached a certain distance. In the case of a group consisting of several orders of stars, one order might thus become nebulous at a certain distance, but with yet greater increase of distance this nebulosity would vanish, and the question whether any new nebulosity would replace it would depend wholly on the question whether the next higher orders of stars belonged to one or other of the classes considered above. Considerations thus applied to a group of stars passing away from the eye, may obviously be extended to star-groups at various distances; and since we could not judge of the distance of the moving group from its resolvability or irresolvability, so neither can we place any reliance on those estimates of the distances of nebulæ which have been founded on their resolution.

Mr. Williams describes some early telescopes made by Giuseppe Campani which he purchased at the sale of the late Dr. Lee's instruments. Readers of the 'Celestial Cycle' and its 'Prolegomena' will not need to be reminded that these instruments were tested by the late Admiral Smyth.

Mr. Powell communicates a paper "On the Double Star α Centauri." The companion has recently reached its lesser maximum of distance, and has commenced its return towards the primary. Thus an exactitude of determination has become possible, which (as Captain Jacob used to remark) was impossible while it remained unknown how far the companion would pursue its northerly excursion. The following are the elements which Mr. Powell now assigns to the orbit:—

Longitude of periaster ..	38°·40	Semi-axis	20″·13
Eccentricity	·63944	Period	76·25
Rising node	24°·18	Periastral passage ..	1874·2
Inclination	81°·13		

These results differ somewhat importantly from those obtained by Sir John Herschel, Hind, and formerly by Mr. Powell himself.

Mr. Seabroke endeavours to show that Mr. Lockyer's theory that the corona is a phenomenon of the earth's atmosphere "is quite possible." For this purpose he considers how far such spectroscopic results as Major Tennant obtained during the Indian eclipse, might be accounted for on that theory. It is unfortunate that in place of dealing with the actual circumstances of that eclipse, Mr. Seacombe determines "what spectrum we ought to obtain from a corona at

a point on the earth where the limbs of the sun and moon are in a line; that is, where the eclipse is total exactly." In any given total eclipse the coincidence of the limbs of the sun and moon is necessarily a momentary phenomenon; and the state of things at the moment is altogether exceptional. What has to be explained before Mr. Lockyer's strange theory can be admitted, is the observed state of things when lines from the sun's limb to the moon's disc fell eighty miles or so from the observer's station. Mr. Lockyer himself has begun to recognize the necessity of explaining away this difficulty, and he now supplements his theory by introducing "a possible action at the moon's limb," though what the nature of that action may be he forbears to indicate.

Mr. Browning gives an account, accompanied with illustrations, of his ingeniously devised automatic spectroscope referred to in our last. When this paper was read before the Royal Astronomical Society, Professor Pritchard stated that he had given several hours to the examination of the optical relations of the new instrument, but could not definitely assert that minimum deviation is secured for rays of all orders of refrangibility. Although the instrument is probably as perfect practically as it can be made by whatever further refinements may be adopted, it requires but little consideration to show that it does not in its present form theoretically secure true minimum deviation for all rays. The fixity of the first prism (the collimator being also fixed) suffices to prevent this. We believe that Mr. Browning is now at work on a modification of his instrument which has been suggested to him, in which this objection is obviated.

Fr. Perry, of the Stoneyhurst Observatory, gives an account of an observation made on Winneeke's new comet (discovered on May 30, at Carlsruhe). He had searched in vain for D'Arrest's comet. Mr. Hind sends the elements (calculated by Winneeke himself) of the former comet, which is described as a round pretty bright nebula, about $2\frac{1}{2}$ minutes in diameter.

Lieut. Hill, on May 22, saw three large spots on the sun, with the naked eye. On the following day a fourth spot was visible. We believe that this is the first instance on record in which so many spots have been seen without telescopic aid.

In a paper on the stereographic projection, Professor Cayley points out that the very same circles which in the direct stereographic projection of a hemisphere (*viz.* that wherein the projection is on the plane of a meridian) represent the meridians and parallels respectively—represent also in the oblique projection of the hemisphere meridians and parallels respectively.

Mr. Lynn discusses the proper motion of the star "Groombridge, 1830." He finds as the final result of his examination of the

Greenwich records of this star, the following mean annual proper motions in four several intervals:—

Years.	Proper Motion in R. A.	Proper Motion N. P. D.
1845–1850	+0ˢ·358	+5″·82
1850–1860	0·343	5·73
1860–1864	0·336	5·93
1864–1869	+0·338	+5·71

We may fairly assume that the mean of these values (properly weighted) represents the true value of the star's motion—which it will be seen is exceptionally large.

4. BOTANY.

Evaporation of Water from Plants.—Some researches have recently been undertaken by Von Pettenkofer on the amount of evaporation which takes place from the foliage of plants. The experiments were made in the case of an oak tree, and extended over the whole period of its summer growth. He found the amount of evaporation to increase gradually from May to July, and then decrease till October. The number of leaves on the tree were estimated at 751,592, and the total amount of evaporation in the year at 539·16 cubic centimètres of water for the whole area of the leaves. The average amount of rainfall for the same period is only 65 cubic centimètres; the amount of evaporation is thus $8\frac{1}{2}$ times more than that of the rainfall. The excess must be drawn up by the roots from a great depth; and thus trees prevent the gradual drying of a climate, by restoring to the air the moisture which would otherwise be carried off by drainage.

Germination of Palms.—Mr. J. W. Jackson, Curator of the Museum at Kew, has published a useful paper "On the Germination of Palms." This is incorrectly described in all the botanical text-books commonly in use. The peculiarity consists in the end of the cotyledon remaining in the seed, whilst its stalk is pushed out, carrying with it the radicle, which germinates in the usual manner at a little distance from the seed. In the double cocoa-nut, *Lodoicea*, the protruded end of the cotyledon is as much as 12 or 18 inches long. The sheath or socket at the base of the stem of this palm is shown not to be peculiar to it, as has been supposed, though more developed than in other species, and to be formed by the vascular bundles of the rudimentary and early leaves.

Existence of a Formative Layer in the Leaves of Plants.—M. Cave has recently pointed out that a formative layer exists in the leaves of plants, similar to the well-known cambium layer, which, in exogenous plants, intervenes between the bark and the

wood, and from which the new wood is formed. He finds it not only in the leaves, but in all foliar or "appendicular" organs, normal or modified, as for instance the flowers, but occupying a different position to the cambium layer, namely, between the tissue of the organ itself and the epidermis. The knowledge of this fact M. Cave applies to determine a morphological question which is often a matter of controversy, whether a particular organ belongs to the axis, to the foliage, or to both sets of organs combined; and he shows that if the formative layer is exterior to the fibro-vascular system, the organ belongs to the leaves; if interior to it, to the stem. The application of this test proves that the receptacle-like perigynous calyx of many plants is a dependency of the axis; while the pericarp of superior fruits is always formed of metamorphosed leaves and nothing else; this is also the case with the axile and parietal placentæ; but the free central placenta, as in the case of *Primulaceæ*, is a prolongation of the axis. Fruits proceeding from an inferior ovary are composed of two parts, varying in their mutual proportion in different plants, a receptacle-like calyx and carpellary leaves. It is noteworthy that M. Cave found this formative layer to occupy the same position in the leaves and fruits of endogens as in those of exogens.

Changes in the Colour of Flowers produced by Ammonia.—M. Vogel has recently published the results of some experiments on the changes produced by ammonia in some vegetable colours, especially those of flowers, which he thinks may be of practical importance in the manufacture of vegetable colouring matters of a character similar to the aniline dyes. The colouring matter he states to be of two kinds, united with a different degree of persistence to the tissue of the flower itself, and requiring a shorter or longer time to produce any alteration. The change produced in the colour of some flowers, as the rose and phlox, by the fumes of tobacco, is entirely due to its ammoniacal element. M. Vogel found that some colours are altogether unchanged by lengthened exposure to ammonia; as, for instance, yellows, all reds (except in the case of the *Zinnia*, which is converted into a brown-red), and dark violets. Blue is sometimes unaltered, sometimes changed into a dirty green and then bleached. In some cases, not only the colour but the tissue of the flower is destroyed. The changes are generally the same as those that take place during the withering of the flower.

Electricity in Plant Life.—A writer in the 'Gardener's Chronicle' points out the important part played by electricity in the phenomena of vegetable life. He states that every hair and sharp point in the vegetable kingdom is necessarily a conductor of electricity, which must always be present wherever water rises in the form of vapour. Hence all the young and growing parts of

plants are clothed with delicate hairs; and the same is generally the case with those fruits or other parts which have a very fine and delicate scent or flavour, these qualities being, the writer believes, greatly developed by the agency of electricity.

Poisoning by Œnanthe crocata.—Mr. Worthington G. Smith records an instance of poisoning by the water dropwort, *Œnanthe crocata*, a common Umbelliferous plant in the South of England. A carter, whilst at work, ate some of the roots, supposing them to be wild parsnips; in about an hour he became unconscious and convulsed, and death occurred in another half-hour, before medical assistance could be obtained. The man had fed his horse with roots of the same plant, and the animal also expired about two hours after eating them. The plant belongs to that group of narcotico-acrid poisons comprising the *Solanaceæ* (Belladonna, Hyoscyamus, &c.), and characterized by producing convulsions with delirium. The juice of the plant was in this instance of a yellow colour; it has been stated that a variety of the plant with colourless juice is a less virulent poison. The taste of the root is said to be intermediate between that of celery and turnip.

Mistletoe on the Oak.—Dr. Bull records, in the 'Transactions of the Woolhope Naturalists' Field Club,' a very interesting case of this extremely rare occurrence. The tree grows in the hedge-row of a field called the Harps, at Haven Aymestry, in the ancient forest of Deerfold, in Herefordshire. It was discovered in the spring of 1869, but the mistletoe must have been growing on the oak for some years. The oak is of the variety *sessiliflora*, and may be some fifty or sixty years old. The mistletoe is a female plant, and grows high up on the main stem. It forms a large spreading bunch, with a diameter of 3 feet 6 inches, and springs out from the oak in a single stem, nearly 4 inches in circumference. The mistletoe is also growing on a thorn close by, and has probably sprung from a seed dropped by a bird from above. The great rarity of the growth of mistletoe on the oak is proved by the fact that there are but eight examples which have been well authenticated as existing at the present time; the localities being Eastnor Park, Herefordshire; Tedstone Delamere, Herefordshire; Forest of Deerfold, Herefordshire; Frampton-on-Severn, Gloucestershire; Sudbury Park, Monmouthshire; Dunsfold, Surrey; Hackwood Park, Hants; and one near Plymouth.

The Cinchona in the West Indies.—In a recently-issued Colonial Blue-Book, Sir James P. Grant, the Governor of Jamaica, states that the cinchona plantation in that island may now be pronounced a complete success. Cinchona plants were first received in 1866. By the close of 1867 the number of young plants had so much increased, that it became necessary to provide land for their final establishment on a planter's scale. Six hundred acres of

virgin forest in the Blue Mountain were acquired early in the year, and were set apart for the purpose of a cinchona plantation, for which the place is in every way admirably suited. The elevation varies from 4000 to 6000 feet. It is well watered, has the best aspects, and possesses a soil reported to be admirably adapted to the requirements of the cinchona. Fifty acres were cleared, of which forty were filled with cinchonas in the course of the year; about 20,000 plants of five different species having been planted. By the latest accounts all of these were in full vigour, and the plantation must by this time be doubled in extent. The plants have stood one of the driest seasons that has ever been remembered on Blue Mountain, without suffering in the least. There is now no doubt that the cinchona can be successfully reared in Jamaica.

Origin of Prairie Vegetation.—Professor Winchell, of the University of Michigan, has recently promulgated a new theory respecting the origin of the vegetation of the American prairies, namely, that it dates back beyond the historical epoch to the Glacial period. He believes the origin of the prairies to be lacustrine; but, contrary to the generally-received opinion, he maintains that lacustrine sediments contain no living germs. Diluvial deposits, he states, on the contrary, are found everywhere replete with living germs, which, when hidden away from the influence of light and moisture, retain their vitality or power of germination for an indefinite length of time. These living germs of the diluvial deposits he believes to have been buried during the glacial period, in the course of which the surface was ploughed up by glaciers, and afterwards exposed to the commotion of the sea, which overspread the land, burying everything in promiscuous ruin; but yet by this very means storing away the seeds which, when brought to the surface after the lapse of a geological age, are possessed of vitality, and able to reclothe the barren earth with verdure and beauty. Thus, in proportion as the diluvial surface became exposed, the flora of the pre-glacial epoch was reproduced. In support of this theory, he brings forward the argument that the fossil plants which have been discovered in the tertiary deposits show a correspondence of genera, and in some cases even of species, with those existing at the present time.

The Herbarium of the British Museum.—The Curator of the British Museum Herbarium has just published his annual report of the national collection. A considerable number of families have been re-arranged, and collections incorporated in the general herbarium from Mexico, New Granada, Nicaragua, Ecuador, California, India, and other countries. The most important additions to the herbarium have been 2000 plants from Abyssinia, and upwards of 3000 from South Africa, as well as more than 1000 European plants, and a number of smaller collections. Various portions of

the British herbarium, and the collection of fruit and seeds, have been re-arranged, and the recent and fossil *Coniferæ* and *Cycadeæ* have been examined and arranged.

The Botanic Garden at Brussels.—The Belgian Government recently purchased the magnificent collection of dried plants of the late Von Martius as the nucleus of a national herbarium. It has more recently concluded the purchase of the Botanic Garden belonging to the Horticultural Society of Belgium; and has thus commenced the formation of a national establishment intended to rival those of Paris and London.

5. CHEMISTRY.

Of all the non-metallic elements, fluorine appears the most difficult to bring under the domain of organic chemistry; very few compounds of this element with carbon, hydrogen, and nitrogen being known. Dr. R. Schmitt and H. von Gehren have recently succeeded in preparing Fluorbenzoic acid and Fluorbenzol. Fluorbenzoic acid is prepared from diazo-amidobenzoic acid by treating that substance at a high temperature in a platinum basin with hydrofluoric acid. The fluorbenzoic acid thus obtained resembles, as far as its physical properties are concerned, benzoic acid; it is, however, far more volatile, fuses at 182° C., is difficultly soluble in cold, readily in hot water, and soluble also in ether and alcohol; its aqueous solution exhibits a strongly acid reaction to test-paper and decomposes inorganic carbonates very readily; the acid does not act upon glass, and is a very fixed substance, which may be even dissolved in concentrated sulphuric acid without decomposition. Fluorbenzol is a crystalline solid, boiling at about 183° C., fusing at 40°, insoluble in water, and specifically heavier than that liquid, readily soluble in ether and alcohol.

Whilst organic chemistry is aptly called the chemistry of carbon, Drs. Friedel and Ladenburg are engaged in researches which tend to place silicium parallel to the former element. They have succeeded in preparing what they call silico-propionic acid, a compound wherein a large percentage of the carbon of propionic acid is replaced by silicium. The physical aspect and many of the properties of this body are akin to silica; but it is a combustible substance, insoluble in water, but soluble in a hot and concentrated solution of caustic potassa. M. Dumas observed, in reference to this paper, that it is not impossible that there exist in nature organic compounds of silica, a remark which gave rise to some observations on Dr. Friedel's 'Memoir,' by P. Thenard. The author begins with stating that M. Dumas is quite right, and

relates further that he (M. Thenard) is at present engaged on researches of organic acids which contain even 24 per cent. of silica entirely disguised. When ulmic acid is treated by ammonia, azhumic acid is formed; this contains nitrogen so fixedly, that it is only eliminated at a temperature of about 1200°. This acid is possessed of the remarkable property of readily dissolving silica, and combining therewith in the same manner as the compound alluded to above by Dr. Friedel. The author also states that although his researches on this subject are not yet quite concluded, he is justified in stating that all arable and garden soil, and far more so farmyard manure, contain similar organic silicious compounds which play an important part in the feeding of the plants.

That indefatigable savan, the Abbé Moigno, has recorded that when picric acid is introduced into a vessel containing ozone, a violent detonation instantaneously takes place, a new proof of the danger attending experiments with nitrogenous compounds containing nitrogen only loosely bound.

The utility of mixing peroxide of manganese, for which, however, may be substituted substances such as peroxide of iron, oxides of zinc and tin, burnt gypsum, and others, provided they are previously well dried (best by ignition) with chlorate of potassa, is based according to Dr. G. Krebs upon the fact that the substances alluded to, which are infusible by themselves, are the carriers and transferers of heat to the chlorate of potassa, each particle of which is surrounded with a source of heat, which aids its rapid decomposition. The peroxide of manganese is prevented from being itself decomposed, because the chlorate of potassa withdraws from it heat, for the purpose, first of its own fusion, whereby heat becomes latent; secondly, by its decomposition. The author states that when oxide of iron, or peroxide of manganese, is strongly heated in a crucible, and chlorate of potassa very gently fused at the same time by itself in a porcelain dish, the addition of the moderately hot oxides to the fused chlorate causes the evolution of oxygen to set in instantaneously, and with so great violence, that unless this experiment be performed in open vessels and with small quantities at a time, serious explosions may occur.

A compound of hydrogen and mercury, which the discoverer calls Hydrogenium-amalgam, has been prepared by O. Loew, by shaking together in a vessel, to be kept very cool, a mixture of mercury containing from 1 to 2 per cent. of metallic zinc, along with an equal bulk of a solution of chloride of platinum containing 10 per cent. of solid chloride. A slimy mass is obtained, devoid of metallic lustre and prone to decomposition, owing to the presence of zinc and some compounds of that metal; but on treating the mass with dilute hydrochloric acid, a body having the consistence

of butter is obtained, which according to the author is a true amalgam of mercury and hydrogenium. The author describes at length several reactions of this body, which in many of its properties is akin to hydrogenium-palladium. Professor C. A. Seeley, speaking of this amalgam and the allied ammonium amalgam, gives it as his firm opinion that they are only mechanical mixtures of mercury and gases. In illustration of this he describes an important experiment to prove that if ammonium amalgam be subjected to varying pressure, its volume changes, apparently, in accordance with Mariotte's law of gaseous volume. To illustrate this, a glass tube $\frac{1}{3}$ inch in diameter, 20 inches long, and fitted with a plunger, was employed. Mercury containing a little sodium was poured into the tube to $\frac{1}{3}$ inch in depth; and upon this was poured a strong solution of chloride of ammonium occupying about 2 inches in length of the tube. The ammonium amalgam was completely formed in a few minutes, and occupied several inches of the tube. On adjusting and depressing the plunger, the volume of the amalgam progressively diminished till it closely approached the original volume of the mercury. Also, it was notable that the amalgam progressively gained fluidity and the mirror surface till, at the greatest pressure, the original volume and appearance of the metal were resumed, whilst on reducing the pressure below that of the air, the amalgam still expanded until it rose above the surface of the liquid in the tube. If the great pressure be maintained, more ammonium amalgam will be formed, the mass expanding progressively, apparently in accordance with the fact that the absorption or adhesion of gases to liquids is favoured by pressure. By means of the simple apparatus used, a pressure of ten atmospheres or a good vacuum are easily and at once obtainable, and the experiments with it are very striking. The considerations regarding ammonium amalgam are evidently equally applicable to Loew's hydrogenium amalgam; both may be only metallic froths. The expansion of palladium observed by Graham, on its absorption of hydrogen, is probably analogous to the case in question. In both cases, the gases concerned are condensed, by reason of their attraction to the metal; and if the molecules of palladium were made free to move, as those of mercury, it is probable that Graham's hydrogenium alloy would become a palladic froth, more remarkable than the corresponding mercuric froth.

The presence of manganese as an essential constituent of milk and blood (human as well as animal) has been known for about twenty years past, but E. Pollacci gives some particulars about the method of detection of this metal in the two animal fluids referred to. The milk which contains this metal in the largest proportion is first evaporated to the consistency of a paste; this is carbonized by heat in a platinum crucible; the charcoal thus obtained is

pulverized and next completely incinerated; the ash is triturated in an agate mortar and lixiviated with water; the residue is treated with very pure nitric acid, and the solution thus obtained is evaporated to dryness and calcined in a test-tube; after cooling, a few drops of nitric acid are added, and the contents of the tube again boiled; next a few grains of puce-coloured oxide of lead are added and the liquid again boiled; a more or less deeply purplish-coloured liquid appears on leaving the tube at rest for a short time, which is due to the formation of permanganic acid. No quantitative researches have as yet been made by the author.

All chemists must have suffered inconvenience by finding that their test-solution of tartaric acid had become mouldy. Many remedies for this decomposition have been suggested, but none appear so simple as the one proposed by William H. Wood, of Middlesbro'-on-Tees. This chemist has made known that if a solution of tartaric acid in water, whether mouldy or not, be filtered and then boiled for a short time (say ten minutes), it will not afterwards become mouldy, whether corked or stoppered up in a bottle, or left exposed to the air. This statement will, if confirmed, be important as bearing on the so-called "spontaneous generation" controversy, and may throw some light on it.

The production of a crystalline alloy of zinc and calcium has been observed in the preparation of calcium by the process of M. Caron, in which an excess of zinc was employed. It contains about 95 per cent. of zinc and 5 per cent. calcium, corresponding to the formula $Zn_{12}Ca$. These crystals are small octahedrons with square bases. They are acted upon by water with the liberation of hydrogen.

Dr. W. Stein has devised an easily-executed process for the detection of madder colours upon cloth or by themselves. He boils the cloth with a concentrated solution of sulphate of alumina, whereby a liquid is obtained of reddish colour, exhibiting a golden-greenish fluorescence, due to the presence of purpurine; the behaviour of the colouring matters of madder towards sulphate of alumina is so characteristic that this salt may serve as an effective test for these substances; the alizarine may be readily rendered soluble by treating the dye material or dyed cloths with alcohol acidified with hydrochloric acid.

As a result of a lengthy series of experiments, M. E. Baudrimont concludes that tin-foil, in consequence of its impermeability for water, may serve with great effect to protect various substances from the effects of the atmospheric moisture, as well as act as a protective against the alterations fruit undergoes by evaporation of the fluids therein contained; tin-foil also protects against the oxidizing action of the oxygen of the atmosphere, and may hence serve

to keep fatty substances from becoming rancid, while it may usefully serve in laboratories to wrap up caustic lime, bisulphite of soda, and similar substances, which may thus be preserved for a great length of time without deterioration.

The cause of the precipitation of muddy matter from water by the aid of dilute saline solutions has been investigated by Dr. Ch. Schlasing. Water otherwise pure, but contaminated simply with clay (as may be the case with the water of rivers after heavy rain or fall of snow), becomes at once clarified by very minute quantities of some salts of lime: $\frac{1}{1000}$th part of chloride of calcium for 1 part of water effects this purpose in a moment; the nitrate, bicarbonate, and caustic lime act in the same manner. The precipitated substance may be readily separated from the water by filtration, whereas the filtration of the water containing the suspended matter is very difficult, because the pores of the filters become choked. The practical importance of this matter is very great, since it is, for instance, a well-known fact that the water of some rivers (the Durance being notorious in this respect) does not, in winter time, and after heavy rainfall or snow-storms, become quite clear, even if left at rest in large ponds for a considerable time. The same is the case with the water of the Rhine, which in its lower course is often turbid for weeks together, simply from the effects of very finely-divided clay being suspended even after the water has been at rest in tanks. The water of the river Durance supplies Marseilles with fresh water, the latter being brought to that city by a magnificent series of works, among which may be mentioned the celebrated Aqueduc de Roquefavour. Certain bitter vegetable substances have been applied both in Egypt and in India, for the purpose of rendering the waters of the Nile, Ganges, Indus, and other large rivers, potable, many centuries before the *rationale* of the action of these substances was understood.

6. ENGINEERING—CIVIL AND MECHANICAL.

The Mitrailleur.—Unfortunately the peaceful progress of Engineering Science has, within the last few weeks, been suddenly interrupted by the outbreak of hostilities on the Continent; and prominence has consequently, for the time, been obtained by that branch of engineering which devotes its energies to the production of warlike engines and materials. For some years past attention has been given to the improvement of our artillery, and the revival of breech-loading cannon, which for a while was received with much favour, is already beginning to find strong opponents from the fact that, as a rule, they possess less precision than the old muzzle-

loaders. Steel and chilled iron also appear likely again to give place to bronze as a material for field guns. The arm of the day is, however, the mitrailleur, or mitrailleuse as it is sometimes called, which has already performed such bloody work in the present war. The mitrailleur belongs to the same class of weapon as the revolver, having, however, this advantage, that its barrels may be fired almost simultaneously. One of the earliest of this class of weapon was the American Gatling gun, which was first seen in Europe at the Exhibition of 1867. This consists of six barrels mounted in two rings of iron, fixed on a central axis; at the rear of these are two half-cylinders of iron, bolted together, which serve to enclose and protect the mechanism; within these a cylinder revolves, with grooves into which cartridges fall as it is turned round, and by a self-acting mechanism they are pushed forward into the barrels, fired, and the empty cases subsequently extracted. A continuous and rapid fire can thus be maintained as long as there remains ammunition at hand to continue feeding the breech. The mitrailleur which has recently been subjected to comparative and experimental tests at Shoeburyness, is of Belgian origin; it was introduced into this country by Major George Fosbery, V.C., of the Bengal Staff Corps. It was invented in 1867 by M. Montigny, but has received several modifications and improvements since that date. This weapon consists of thirty-seven steel barrels, of an hexagonal form exteriorly, fitted and soldered together, and finally surrounded by a wrought-iron tube. To the tube or barrel thus constituted a breech attachment is screwed, and the two together, with the movable breech-block and its lever, form the gun. In outward appearance the gun looks like a solid steel block about four feet long, pierced with thirty-seven holes. A cartridge holder, consisting of a steel plate with holes corresponding in position with the barrels of the gun, being filled with central-fire cartridges, is inserted in the breech-piece and held in its place by suitable arrangements, whilst by the movement of a handle on the right-hand side of the gun, corresponding plungers are released, and striking their respective cartridges fire the gun. According to the rapidity with which this handle is moved the barrels may be fired one by one, or in a volley. The weight of each projectile is 600 grains, and the charge 115 grains. It would be premature at present to give any results of the experiments now being carried on. It may be here stated that Major Fosbery estimated the speed at which the mitrailleur could be fired at ten rounds per minute, but this rate has not yet been nearly attained in practice.

Steam and Air Engines.—Although the union of steam and air for the purpose of effecting economy in engine working is by no means a new invention, yet the means adopted for effecting this object which have recently been made public, appear to be so far

superior to what has previously been introduced, as to warrant some prominence being given to the subject. Some years ago a steam-engine used in an industrial establishment at Muhlhouse in France, was converted into an aëro-steam engine by the simple addition of a pump to force air into the boiler; a considerable increase of power was stated to have been thereby secured, but its success does not seem to have continued long, and the experiment did not then secure much general favour. Recently, however, the subject has been revived, and two inventors claim the support of the public on behalf of their respective inventions. The first of these is Parker's steam and air engine, and the second Warsop's aëro-steam engine; the general principles involved in each are the same up to a certain point, but the methods of applying them differ considerably. In Parker's engine the air is drawn directly into the steam-pipe, leading from the boiler to the engine, by means of the force of the steam passing through it; this steam-pipe is sometimes passed through a small coke fire, in order to raise the temperature of the united steam and air, but this is not considered in any way essential to the utility of the apparatus. Experiments made with it are reported to have resulted in considerable economy of fuel combined with increased efficiency of engine power.

Warsop's aëro-steam engine consists in the use of an air-pump, worked either by the steam-engine itself, or by a donkey-engine; this pump takes in cold air which, after being compressed, is forced on through an air-pipe passing through the smoke-box, or some other part of the boiler where heat can be taken up from contact with the waste gases. The highly-heated air passes a self-acting clack-valve into the bottom of the boiling water, and is so distributed by simple mechanical means, that it rises constantly through the water. On rising above, the air is saturated by the steam, and the two together pass on to their duty in the cylinder. From a series of experiments carried out with this engine at Nottingham, it appears that in the amount of useful work done for fuel expended, the advantage rested with the combined steam and air system, as compared with when steam only was employed.

Thames Embankment.—Upwards of eight years have now elapsed since the reclamation of the foreshore of the Thames between Westminster and Blackfriars Bridges was undertaken by the Metropolitan Board of Works. This magnificent boulevard was opened on 13th of July last. It consists of a roadway 100 feet in width throughout, having on the river-side a foot pavement 20 feet wide, and on the opposite side one of 16 feet; the former is edged by a row of trees, planted at intervals of 20 feet. The total amount of land reclaimed is $37\frac{1}{4}$ acres, of which the carriage-road and footways occupy 19; 8 acres will be converted into ornamental gardens for the public use, and the remaining $10\frac{1}{4}$ acres pass over to the original

proprietors of the foreshore. From the official description of the Victoria Embankment, it appears that the works and material employed comprise 144,000 cubic yards of excavation, 1,000,000 cubic yards of earth filling, 140,000 cubic yards of concrete, 80,000 cubic yards of brickwork, and 650,000 cubic feet of granite. The total cost of the works has been 1,260,000*l.*, and the amount paid for compensation 450,000*l.* Beneath the roadway lies hidden a portion of the London main sewage system, above which is a subway, behind the embankment wall; on the opposite side, the works of the Metropolitan District Railway have been carried on contemporaneously with the Embankment, and there are four stations, namely, at Westminster, Charing Cross, the Temple, and Blackfriars, accessible direct from the roadway. Communications will no doubt shortly be completed between the Embankment and the several roads leading southwards from the Strand, as without such connections this handsome new boulevard would be deprived of half its value as a means of communication; according to an existing Act of Parliament, however, the right to make such connections is prohibited.

Chatham Dockyard Extension.—For some time past extensive works have been in progress for the extension of Chatham Dockyard. They are being executed upon 380 acres of land, and comprise, amongst other works, the reclamation of a marshy tongue of land known as St. Mary's Island, which was formerly submerged at high water; in addition to which the scheme includes the construction of a series of three extensive docks along the line formerly occupied by St. Mary's Creek, and the erection of workshops. The reclamation of St. Mary's Island has necessitated the erection of a considerable portion of embankment and river-wall, the latter consisting of a brickwork face with concrete backing; the island was then raised, by means of spoil tipped upon it, to a level well above high-water mark. The first basin, next Chatham Reach, has an area of 22 acres; it will be used for repairs, and is furnished on its south side with four large graving docks, the first stone of which was laid on 21st April, 1868. The middle, or factory basin, 20 acres in extent, will be provided with factory buildings on the southern side, including fitting and erecting shops, boiler shops, smithy, foundry, stores, &c.; whilst on the northern side will be the camber for a floating dock, a docking platform, and ten slips for laying up frigates, with the necessary worksheds. The third, or fitting-out basin, into which vessels entering for repairs will pass to be dismantled prior to going into the other basin, or, if leaving, they will be rigged and receive their supplies and stores, is 33 acres in area. The repairing basin, with its graving docks, and the communication with the factory basin, are expected to be opened in April next. The factory basin will probably be opened by the end of 1871, and the works of the other basin are also in a forward state.

Meetings of Societies.

Institution of Mechanical Engineers.—The meeting of this Society was held at Nottingham on the 3rd August last. Amongst the papers read were the following:—"On Self-acting Machinery for Knitting Hosiery by Power," by Mr. Arthur Paget, of Longborough; "On the mode of working Coal in the Midland Counties," by Mr. George Fowler, Manager of the Hucknall Colliery; "Conclusions derived from the Experience of Recent Boiler Explosions," by Mr. E. B. Marten, Chief Engineer of the Midland Boiler Assurance Company; and "On a Self-acting Safety and Fire-extinguishing Valve for Steam-Boilers," by Mr. G. D. Hughes. Space will not admit of our giving a reasonable abstract of all the above papers; we shall therefore confine ourselves to a few remarks on the first and last two mentioned subjects. Mr. Fowler's lectures are reviewed elsewhere.

Self-acting Machinery for Knitting Hosiery by Power.—The date at which appliances for knitting have been brought within the limits of machinery is very recent. It is one of the greatest peculiarities of the hosiery manufacture that it shapes wearing apparel without the intervention of the tailor or of the milliner; thus there exists a necessity that the machines employed should be easily adapted to make articles of very great variety of shape, thickness, and degrees of elasticity. Mr. Paget gave a description of a self-acting power-frame of his own invention, which, on account of its necessarily great complication of parts, it would be impossible to describe without illustrations. A skilful framework knitter with his hand-frame would, it was stated, knit about 5400 stitches per minute; whereas a girl could, on the same work, attend to three of Mr. Paget's self-acting machines, making in the aggregate 40,500 stitches per minute.

Boiler Explosions.—Mr. Marten remarked that from the result of the experience of the last four years, he was enabled to confirm the opinion he previously held, that all boilers, however good in original construction, are liable, in the course of time, to get into bad order and explode. The causes of explosions appear to be three, *viz.*—1. Faults in construction or repair; 2. Faults in working, which creep on insidiously and unnoticed; and 3. Faults which might be seen and guarded against by careful attendants. Nearly all the faults would be detected by periodical examination, which is indeed the only true safeguard against explosions. Each cubic foot of water has the explosive effect of one pound of gunpowder, and the explosion of a boiler assimilates more nearly to that of gunpowder than of any other explosive agent. Mr. Marten enters into some detail regarding the various explosions that have come under

his notice, and sums up with some very excellent rules for the avoidance of such disasters.

Safety-Valve for Steam-Boilers.—This apparatus is intended to serve the double functions of fusible plugs and low-water alarums. An internally loaded valve of spherical form is placed in a steam-chamber, and a pair of steam-pipes connect this chamber with the furnace crown of the boiler. The safety-valve is dead weighted, and should the pressure of steam lift it up, it escapes into the chamber and down the pipes into the furnace. Any over-pressure is thus dealt with, and the motion of a float is made to act in a similar way on the same safety-valve. Another independent safety-valve is adjusted to blow off at a pressure somewhat lower than that at which the dead weight is adjusted.

Liverpool Polytechnic Society.—A very interesting paper was recently read before this Society by Mr. T. B. Thorburn, C.E., Surveyor to the Birkenhead Commissioners, "On the method adopted in Birkenhead for Ventilating Sewers, and carrying away the Gaseous Emanations generated therein." This paper, which it would be impossible to follow in detail, contains an account of the extent of the Birkenhead sewers, and not only states the different ventilators employed, but gives also the cost of constructing them according to the several arrangements adopted.

7. GEOLOGY AND PALÆONTOLOGY.

(*Including the Proceedings of the Geological Society and Notices of Recent Geological Works.*)

Professor John Phillips, M.A., D.C.L., LL.D., F.R.S. &c.—Few men have by their own labours contributed a larger share to the advancement of scientific knowledge than Professor Phillips, and we are glad to obtain a sketch of his career,* which is probably as full of noble achievements as that of any scientific man we have ever known. Brought very young (by the death of his father) under the care of his uncle, William Smith, originally known as "Strata Smith," and afterwards called "the father of English Geology," he was early led to take delight in the identification of strata by their fossil contents, and accompanied his uncle through the greater part of England during his geological investigations, which resulted in the first geological map of England and Wales. Few men of science have had a more distinguished career. Appointed Keeper of the Yorkshire Philosophical Society's Museum in 1825, that Society grew and flourished under his care, and led in

* 'Geol. Mag.,' vol. vii., 1870, p. 301.

1831 to the establishment of the British Association, of which he became the Assistant General Secretary in 1832, and continued to act in that capacity until 1863. In 1834 he became Professor of King's College and a Fellow of the Royal Society. In 1840 he resigned York Museum, and entered upon the duties of the Geological Survey of England and Wales, to which he contributed Memoirs on the Palæozoic Fossils of Cornwall, Devon, and Somerset, and afterwards on the Malvern Hills, &c. In 1844 he became Professor of Geology in the University of Dublin. In 1849 he was appointed one of Her Majesty's Commissioners to inquire into and report upon the system of ventilation employed in mines. In 1853 he commenced the duties of the Chair of Geology at Oxford, which he has continued to hold ever since the death of Dr. Buckland. In 1859 he was elected President of the Geological Society of London; in 1865, President of the British Association. His various geological works are above seventy in number, and his astronomical and other papers are also very numerous. Besides the York Museum which enjoyed the advantages of Professor Phillips's attention, the present Oxford Museum may be said to have been created by him, and is a model for any city in the world to copy.

Lecture on Volcanoes.—Mr. David Forbes, F.R.S., recently* delivered an interesting lecture at St. George's Hall on Volcanoes. Speaking of the relative energy displayed by volcanic forces in the older geological periods, Mr. Forbes said, "We must bear in mind that we still have volcanoes whose craters, several miles in diameter, send forth at times streams of molten stone forty miles and more in length, or showers of ashes which bury the surface of the ground to a depth of 400 feet below them, and, furthermore, see volcanic mountains and islands literally rising up before our eyes to an elevation of even thousands of feet, in what, geologically speaking, is but a second of time, it does not to me seem at all necessary to assume that such internal or cataclysmic forces were so much more energetic in any other period than at present."

The author believes that sufficient importance has not been given to the effects produced by the cataclysmic action of volcanoes. He points out that all the chief features of the earth's surface are due to the elevatory forces within, and that volcanoes not only form the most lofty mountains in the world, but that the backbone of most of the others is composed of eruptive rocks. It must therefore be admitted that the changes effected in the physical geography of the world have resulted from a combination of two great but most opposite agencies, the internal and external, igneous and aqueous, cataclysmic and uniformitarian; and that all the phenomena of nature result from a combination of one or more forces, the same phenomena, at times, being the result of totally different agencies.

* June 19, 1870.

Mr. Hopkins' Method of Determining the Thickness of the Earth's Crust.—Having been some time since challenged by M. Delaunay,* a distinguished French astronomer and mathematician, the late Mr. Hopkins' friend, Archdeacon Pratt, F.R.S.,† writes in his defence and shows what he conceives to be a flaw in M. Delaunay's objections; namely, that the earth is not a simple shell with a fluid interior always revolving in one plane (in which case he admits there would be no possible objection to M. Delaunay's arguments in favour of a comparatively thin rigid crust and a fluid interior), but that it is ever being disturbed by the forces of precession and nutation; and before the rigid crust and the fluid interior could arrive at a state of equilibrium in one position, the axis would begin to assume a new position, and the fluid interior would again be unconformable in its motion to the external shell; and the earth's motion would again be retarded in a small degree, sufficient to interfere with the axial variations to which the earth is ever subject by the laws of precession and nutation. As science advances it is absolutely imperative that in all these questions our conclusions should be in accord with the laws of chemistry and the known terrestrial conditions, as well as the laws of dynamics.

A New Fossil Snake in Greece.—A new fossil *Python* has been lately described by Dr. Ferd. Roemer‡ from the Island of Eubæa. This is the second fossil ophidian found in Greece, and adds greatly to the interest of the Miocene fauna of this old continent, already rendered so important by the discoveries at Pikermi of such a remarkable series of types of African Mammalia, together with the *Hipparion* by M. Gaudry.

A New Labyrinthodont Amphibian from the Coal-shale near Newcastle-upon-Tyne.—Mr. Thomas Atthey, well known to geologists as one of the most indefatigable investigators of the fossil-remains of the Newcastle Coal-shales, has again been successful in bringing to light the skull of a new and remarkable Labyrinthodont reptile, which the authors of the paper,§ Messrs. Atthey and Hancock, have named *Batrachiderpeton lineatum*. The lower jaw was discovered three or four years since, but the cranium has only now been obtained.

It is impossible to contemplate the structure of the roof of the mouth of this curious Labyrinthodont, without being reminded of the arrangement of the parts in that of *Siren*, *Proteus*, and *Axolotl*. The well-armed vomer in particular is very striking. The extensive development of this vomerine armature and the deficiency of bony maxillæ, would seem to ally *Batrachiderpeton*

* 'Geol. Mag.,' vol. v., p. 507. † Ibid., vol. vii., p. 421.

‡ 'Abdruck a. d. Zeitschr. d. Deutschen Geologischen Gesellschaft,' Jahrg, 1870.

§ 'Ann. and Mag. Nat. Hist.,' Series 4, vol. vi., No. 31, p. 56, Pl. I., July, 1870.

to *Siren* and *Proteus;* while the relationship of the vomers to the pterygoids, and the form of the latter, are very similar to what obtains in *Axolotl;* and the alliance with this last-named interesting form would be rendered still stronger, if it should turn out that our new genus has really bony maxillæ, particularly as the premaxillæ are armed with teeth. In *Siren* and *Proteus* the premaxillaries are quite minute and are devoid of teeth. This is not the only instance in which a Labyrinthodont has been found to exhibit an approximation to the *Siren*-type of structure. *Pteroplax* is so related, although its approach is by a different line from that of *Batrachiderpeton.*

Petrified Forest near Cairo.—The fossil-wood which covers the desert to the east of Cairo has long filled the passing traveller on this great eastern high road with surprise. The immense quantity of what seems to be decaying wood in a region described as a "dreary arid expanse, treeless and almost shrubless, rugged with dark-coloured knolls, and intersected by a few dry rain-channels," excites, by the remarkable contrast of the present with what is apparently the not far-distant past, the wonder of the most careless observer. They have, of course, been referred to by travellers in many published books. Burkhardt thought they were petrified date-trees, Holroyd referred them to the Doom-palm, Murray's 'Handbook' also speaks of them as palms. Gardiner Wilkinson refers to branched and thorn-bearing trees as well as palms, also to some jointed stems resembling bamboos. A careful examination by the late Prof. Unger, however, failed to elicit more than a single species, after a most searching examination of a very large series of specimens, and after a personal visit to the spot.

This form, which he named *Nicolia Egyptiaca*, has just been supplemented by a second species brought home by Prof. Owen during his recent visit to Egypt with the Prince and Princess of Wales. Mr. Carruthers has figured and described it as *Nicolia Owenii*,* after its discoverer.

Italian Tertiary Brachiopoda.—Mr. Thomas Davidson, F.R.S., our great authority upon "Lamp-shells," has taken up his pen and crayons to illustrate the Tertiary Brachiopoda of Italy, which he is carrying out most completely in the 'Geological Magazine.' In his introduction he refers to the much-discussed question of development of species. "We are," he says, "far from having discovered the laws which regulate the gradual succession of life; and we are, I fear, much too apt to guess at the origin of species, and to interpret those unknown laws from a small number of incomplete observations. The assiduous researches which, for many years, I have made among the living and fossil species of Brachiopoda have, to a certain extent, imbued my mind with the idea that an indivi-

* See 'Geol. Mag.,' vol. vii., p. 306, 1870.

dual species may have been gradually very much modified in time, so as to suit the conditions under which it had to exist; but at the same time everyone who has studied with any degree of care any class composing the animal kingdom, must frankly admit that there are so many inexplicable sudden appearances of entirely distinct forms, with no apparent links connecting them with those that were antecedent or even contemporaneous, that it is impossible to arrive at any definite conclusions as to what extent species are derived from their predecessors."

New British Brachiopod.—Mr. E. Ray Lankester describes a new species of *Terebratula* from the (Portlandian ?) "Drift" of East Anglia, which he has named *T. rex;* it is a remarkably large form.

Cephalaspis Dawsoni, sp. nov.—The same gentleman describes a nearly perfect Cephalaspidean Fish from the Silurio-Devonian beds on the north side of Gaspé Bay, Canada, associated with plant-remains. It is named after Principal Dawson, of Montreal.

The Structure of the Crinoidea, Cystidea, and Blastoidea.—We have lately received considerable additional information upon this subject from the pen of Mr. E. Billings, the able Palæontologist to the Geological Survey of Canada.* In the first part of his paper Mr. Billings considers the position of the mouth in relation to the ambulacral system.

Earlier palæontologists described the large lateral aperture in the Cystidea as the mouth. Von Buch, Forbes, Hall, and Billings himself, in his first paper, adopted the view that this was not the mouth, but an ovarian aperture, and that the smaller orifice, usually situated in the apex, from which the ambulacral grooves radiate, was the true oral orifice. Subsequently (in 1858) Mr. Billings re-investigated the subject, and came to the conclusion that the lateral aperture was really the mouth, or serving as both oral and anal aperture in those species not possessing distinct orifices. The small apical orifice was determined to be an ambulacral aperture.

To this view Prof. Wyville Thomson demurs, on the ground of the want of analogy in the rest of the class. Mr. Billings replies that in this class the position of the various organs in relation to each other, and also to the general mass of the body, is subject to very great fluctuations. Thus the mouth and vent are separated in some of the groups, but united in others; while either or both may open out to the surface directly upward or downward, or at any lateral point. The ovaries may be either dorsal or ventral, internal or external, and associated with either the mouth or the anus, or with neither. The ambulacral skeleton may be imbedded in and form a portion of the general covering of the body, or lie upon the surface, or be borne upon free-moving arms. Although these characters are constant, or nearly so, in the same family, in

* See Silliman's 'American Journal of Science.'

different orders, or remotely allied families, they are extremely variable.

The author proceeds to cite a number of instances in support of his conclusions in which the mouth was altogether disconnected from the radial system, and he figures *Batocrinus icosidactylus, Amphoracrinus,* sp. *Caryocrinus ornatus,* &c.

Mr. Billings next discusses the functions of the pectinated rhombs and calycine pores of the Cystidea. Upon this subject a very able and exhaustive paper was written by Mr. J. Rofe,* to which Mr. Billings refers, and accepts the decision of Dr. Dana, Mr. Rofe, &c., and concludes them to be respiratory organs. The author proceeds to describe these organs in *Codaster, Pentremites,* &c., and then endeavours to show the homologies which exist between the respiratory organs of these palæozoic forms and recent Echinoderms, and lastly, the nature of the "convoluted plate" of the Crinoidea. This plate, like the pectinated rhombs, seems to have been connected with the respiratory system. There can be no doubt that the true explanation of why these respiratory organs occupy so large a proportion of the body of the animal is to be found in the fact that the food was obtained by the motion of the vibratile cilia of the arms, which thus fulfilled, as in so many other invertebrates, the double function of bringing fresh streams of the circumambient respiratory medium into intimate contact with the fluid within the general cavity of the body of the animal; and at the same time of conveying minute animalculæ and other organic particles to the mouth in order to serve as food.

Geological Society of London.

The present number of the 'Proceedings of the Geological Society' contains a rich store of palæontological information, both British and foreign. We have illustrations of Mammalia, Reptilia, Mollusca, Corals, and Plants; and those who delight in long lists of fossils can also fully satisfy their appetites. Nor need the field-geologist grumble, for he also may regale himself on the Neocomian, the Oolite, or the Lias to his heart's content. A valuable contribution to our knowledge of Fossil Corals is from Dr. P. Martin Duncan, "On the Madreporaria of the Australian Tertiary Deposits." The series described is from the province of Victoria, the Geological Survey of which was (until lately abolished) so ably conducted by Mr. Selwyn (now Director of the Geological Survey of Canada). The species described do not belong to the reef-building forms, but to such as now occupy the sea-bottom from low spring-tide mark to the depth where Polyzoa abound. It is interesting to

* 'Geol. Mag.,' 1865, vol. ii., p. 245.

note that twenty genera are now found in the Australian seas, only three of which, however, have species in the Tertiaries, *viz.* the cosmopolite *Trochocyathus*, *Flabellum*, and *Amphihelia*, but the fossil species are quite distinct from those now living. If we may judge by the wide geographical distribution of some of these species we may with safety infer that their range in time was also very much greater than has hitherto been assumed. Allied forms are found living in Japan and China, the Red Sea, the West Indies, and Europe in Miocene times.

The descriptions of the new species are illustrated by thirty-two figures, occupying three double-octavo plates.

There is reason to believe that the Wealden vertebra, now described and figured by Mr. J. W. Hulke, belongs to the same large animal—distinct from any of the known *Dinosaurs*—of which there is a single vertebra preserved in the British Museum, and named by the late Dr. Mantell *Streptospondylus*. The texture of the bone is like the coarse diploë of the elephant's skull, and has led to the belief, by Mr. H. G. Seeley, that it represents a gigantic Pterosaurian; but Mr. Hulke reminds us that an extremely light skeleton does not necessarily prove endowment with flight, and also that all the known flying-reptiles have procœlian vertebræ, whilst the vertebra of *Streptospondylus* is amphicœlian in type. The supply of new and wonderful reptilian remains furnished by the Wealden of the Isle of Wight seems almost inexhaustible, but it is much to be regretted that by far the greater part of these have, of late years, fallen into the hands of a local collector in the island, unable to describe them himself and unwilling to allow them to be worked out and described by anyone else.

Our knowledge of Fossil Botany has been increased by an interesting description of a new fossil fern-stem, so like the recent *Osmunda*, as to justify its describer, Mr. Carruthers, in placing it in the Osmundaceæ. The specimen was silicified so effectually that even the starch-grains in its cells, and the mycelium of a fungus traversing some of them, were perfectly represented. The fossil (which was probably derived from the upper part of the Thanet Sands) has been named *Osmundites Dowkeri*, after Mr. George Dowker, its discoverer.

Professor Owen has ventured upon the difficult task of determining the remains of a number of fossil Mammalia upon the evidence furnished by a series of detached teeth brought home by Mr. Robert Swinhoe, H.B.M. Consul at Formosa, and obtained by him from the apothecaries' shops at Shanghai and at Chung-king-foo (Eastern Szechuen) on the Yangtse-kiang River. They included two species of *Stegodon*, a new *Hyæna*, a new Tapir, a new *Rhinoceros*, and a species of Kaup's genus *Chalicotherium*. From a general agreement in colour, chemical condition, &c., Professor Owen

concluded they all belonged to one and the same period, either to Upper Pliocene or Post Pliocene. Strong objections were raised as to the soundness of the species by Professor Busk, especially to *Stegodon*, *Hyæna*, and *Rhinoceros;* it was also objected by Professor Boyd Dawkins, that there was no proof of their contemporaneity. These teeth, which are extremely various, are sold by the Chinese apothecaries as a very valuable medicine when pounded to a powder. They are described by Mr. Daniel Hanbury in his account of the Chinese Materia Medica.

Mr. Hanbury mentions that Mr. Waterhouse, of the British Museum, has determined the following species:—Molars of the lower jaw of *Rhinoceros tichorhinus*, tooth of *Mastodon;* of *Elephas insignis* (*?*); molars of *Equus;* teeth of *Hippotherium* (two species?); teeth of sheep, stag, bear.*

They are said to come from the provinces of Shen-si and Shan-si, but the demand for them is so great that they are believed to be largely imported from the East Indies, and notably from Borneo.

Mr. Sharp's paper, "On the Oolites of Northampton," is principally of importance because of the recent discovery in this district of vast bands of ironstone, the economic quarrying of which has yielded a characteristic fauna with a decidedly *Inferior Oolite* facies, in beds which had been mapped as Great Oolite ("Northampton Sands") by the Geological Survey, and in which—until quite recently—not a trace of a fossil remain was known to exist.

Mr. Sharp has carefully described the district illustrating his observations by numerous sections and a good sketch-map of its geology, together with lists and localities of the fossils he has been so successful in obtaining. As a rider to the paper, Dr. Wright describes a new and very finely-preserved star-fish (*Stellaster Sharpii*), from the ironstone of the Inferior Oolite, Northampton.

Mr. J. W. Judd, of the Geological Survey of England and Wales, has devoted much time and attention to the Neocomian strata of Lincolnshire and Yorkshire and their correlation with those of north-western Germany and elsewhere. He now gives us the result of his studies, carefully prepared and illustrated with maps, sections, and tables. The Neocomian beds of Yorkshire, &c., appear to be the extreme westerly development of a great mass of strata of the same age stretching over a wide area in Northern Europe. It is also seen that in Yorkshire and in Brunswick the Neocomian series is complete, but in the intermediate districts its lowest member is absent, being replaced by the fresh-water deposits of the German Wealden.

Mr. Ralph Tate supplies two papers, on the Middle Lias in Ireland, and the Lower and Middle Lias in Gloucestershire. No higher member of the Jurassic series is known in Ireland than the

* 'Journal of the Pharmaceutical Society,' 1860.

Lower Lias. The Middle Lias occurs as drift on cultivated fields, &c. Mr. Tate suggests that this drift may have been transported from the Hebrides by glacial action. In the case of Gloucestershire, Mr. Tate endeavoured to apply the numerical test as to the distribution of organic remains in order to show that the zone of *Ammonites Jamesoni* belongs to the Middle Lias, and *A. raricostatus* to the Lower Lias. For the present it is exceedingly difficult to follow these minute divisions until more of their contained fossils have been identified and figured.

In addition to these, we have abstract notices of the Crag of Norfolk and Associated Beds, by J. Prestwich, Esq., F.R.S. Captain S. Hyde on Deep-mining in S.W. Ireland. Dr. E. Bunzel on a Reptilian Skull from Grünbach. Mr. R. J. Lechmere Guppy on Trinidad Fossils. M. Coumbary on the Fall of an Aerolite in Fezzan. Dr. A. A. Caruana on a further discovery of Fossil Elephants in Malta. The Journal is a very stout one, numbering 468 pp. and having fourteen lithographic plates.

8. METEOROLOGY.

The Meteorological Office has issued Part I. of its new publication, 'The Quarterly Weather Report,' for the first three months of 1869. The chief features of novelty presented by this Report are the *fac-simile* representations of the curves of the self-recording instruments. It should be stated that the preparation of plates such as those referred to has been rendered possible by an invention of Mr. Francis Galton's. This is a pantagraph which is capable of effecting reductions simultaneously in different proportions along two rectangular co-ordinates. The proportions selected for the plates have been $\frac{1}{6}$ for the horizontal or time scale, and $\frac{1}{2}$ for the vertical scale. By this means all the information for five days from the seven observatories is condensed into the space of two 4to plates, one for the barograms and wet and dry bulb thermograms, the other for the wind and rain. Scales on both the British and metrical systems are given at each side, so that the readings of the barometers and thermometers may be determined for any epoch. For the wind the scales are in statute and geographical miles.

The letter-press consists of (1) an introduction containing some general remarks, especially on the difficulty of obtaining trustworthy records of wind at land stations; (2) the Report itself, which is a chronicle of the weather for the three months, derived from all sources which were available to the office, with tabular statistics of storms; (3) the tables for the year 1869, giving the monthly and the five-day means of various elements, derived from the hourly tabulated readings of the instruments.

In the appendix Mr. Scott has given a notice of some late easterly storms, which is an attempt to classify them and possibly discover traces of their origin. The number of storms investigated is only twenty-five, evidently far too few to allow of important deductions being drawn, but some very interesting facts come out in the discussion, and we hope that the paper may be followed by others of a similar statistical character.

The price of the Report is very moderate, being only 5*s.* a number. It is published by Stanford.

The Third Annual Report of the Committee has also lately appeared. It shows steady progress in the three departments of the operations of the office—Ocean Meteorology, Storm Warnings, and Land Meteorology of these islands. With regard to the last of these we regret to see that Dr. Stewart has found himself obliged to resign his position as Secretary to the Committee. His services in organizing the system of self-recording observation has been of extreme value to the cause of meteorology in England.

In Part II. of the Report we have the description of some new instruments—Mr. Galton's Pantagraph, above noticed; Beckley's Self-registering Rain-gauge, which is to be introduced at all the observatories; and Dr. Miller's Deep-sea Thermometer, to which we have alluded in a previous number.

The last number of the 'Journal of the Scottish Meteorological Society' is mainly occupied with a paper by Mr. D. Milne Home, "Suggestions for Increasing the Supply of Spring Water at Malta, &c." In our notice of the last paper by the same author, in No. XXV. of this Journal, we said, "The paper consists of a series of extracts from the reports of various observers," and the same words will apply exactly to that now under consideration. Mr. Home in his remarks suggests the old and well-known remedy for local drought, *viz.* extensive plantations. It seems rather a pity that when the Society, as we learn from another part of the journal, is endeavouring to obtain funds from the Government, any portion of its means should be expended in publishing papers on foreign, or at least colonial, meteorology.

In our last number we noticed Dr. R. Angus Smith's paper "On the Detection and Estimation of the Impurities of Air, by the Analysis of Rain Water, and by Washing Bottles of Air." His Sixth Report, as Alkali Inspector under the Board of Trade, has just appeared, and contains much valuable information on the subject, which is, however, too foreign to meteorology to require further notice here.

Mr. Blanford, Meteorological Reporter to the Government of Bengal, has published a paper in the 'Journal of the Asiatic Society,' "On the Relations of Irregularities of Barometrical Pressure to the Monsoon Rainfall of 1868–9." He finds that in both

years an area of relative depression existed in Lower Bengal which took its rise at the beginning of the south-west monsoon in April. "Its position was different in the two years, being in the former in the north-west corner of the Bay of Bengal, in the latter in the hilly country to the west of the Delta. It influenced the vapour-bearing winds from the south by deflecting them towards it; and necessarily, by determining an ascending current, it produced an excessive rainfall to the north of its position, the maximum fall being at from 50 to 150 miles distance from the place where the barometer was lowest. Finally, it impeded the passage of the vapour-bearing winds to the north-west provinces, and thus deprived that region of a great part of its usual annual supply."

Considering the extreme importance to India of the periodical rainfall, papers like this of Mr. Blanford's are of great value and interest.

The Third Annual Report of Mr. Blanford's office has also appeared; it shows a steady progress in the way of systematic organization of the various observing stations in Bengal. We may now hope that the example shown by this Presidency will soon be followed in the other districts of Hindostan.

M. Harold Tarry has published notices of the fall of red rain in Italy on various occasions. The papers first appeared in the 'Bulletin of the Association Scientifique,' and then in the 'Comptes Rendus.' His object is to prove that the occurrence is due to previous dust-storms in the desert of Sahara, and not to the advent of cosmical dust from the regions of space, as Arago and Quetelet formerly maintained. He has examined three recent instances of the phenomenon, *viz.* March 10, 1869, March 24, 1869, February 14, 1870. He says that the sequence of circumstances is the same in all cases. A barometrical depression and a storm advances from north to south across western Europe to Africa, where the sand of the Sahara is set in motion in clouds of dust. A few days subsequently a reverse action takes place: a storm advances from Africa to the south of Europe, carrying the dust with it, which comes to the earth with the rain.

The paper is very interesting, but we must say that M. Tarry has not quite proved his case as yet.

The later numbers of the 'Journal of the Austrian Meteorological Society' do not contain much that is suitable for extraction for this Chronicle. The editors have adopted the practice of giving abstracts of meteorological data from isolated stations, and these cannot be rendered intelligible without the insertion of a large amount of tabular matter. The districts for which such information is afforded are very various. M. Rayet's paper "On the Meteorology of the Isthmus of Suez" is reproduced, in abstract, from the 'Atlas Météorologique' for 1868. Then follow several papers by M. Wojeikoff "On the Meteorology of Russia," which he

has compiled from various disconnected registers of local observations for short periods lying at the observatory of St. Petersburgh. The stations are very widely distributed over Europe and Asia.

The Report of the Central Physical Observatory, by Prof. H. Wild, the Director, consists mainly of an account of the condition of the observatory, and a catalogue and description of instruments. As no report had been published since 1864 it was necessary to take stock, and to publish the account for the information of the Russian public. The only matter of general interest is that Prof. Wild appears to have finally decided not to employ photographic self-recording instruments at the normal stations, owing to their serious initial cost and the expense and trouble of working them.

Dr. Prestel, of Emden, has published a pamphlet entitled 'Der Sturmwarner,' in which he commences by discussing the facts of storms, and the possibility of giving telegraphic intelligence of their approach. On reading this part of the paper we are disappointed to find that Dr. Prestel has not made himself acquainted with the latest facts of the subject. The principle of his storm-warner is similar to that of Piddington's horn circles.

He makes four assumptions.

I. That the barometrical reading at the centre of the storm is 28·78 ins. on the mean.

II. That the wind blows in circles round it.

III. That the diameter of the storm is nearly constant.

IV. That the difference between barometrical readings for a given distance in all parts of the storm, or the "gradient," is constant.

If these four postulates be granted, the use of the transparent diagram is perfectly simple and intelligible, but as there is no foundation for any one of them, the whole reasoning falls to the ground.

Another book the utility of which we fail to discover, although it has been favourably noticed in some newspapers, is 'The Wind in his Circuits,' by Lieut. R. H. Armit, R.N.

The author proposes to subvert Maury's theory of the wind by facts drawn from his own experience. A few examples will suffice to show the character of his arguments. The italics are his:—

"The trade winds are very damp moist winds, heavily charged with vapour: every cubic inch of them containing millions upon millions of minute globules of water. On entering the equatorial calm belt, the process these globules undergo is simply that of being turned into *steam*."*

"The easterly wind is formed *of compressed vapour or steam*."†

"Lightning and thunder are caused by the 'Arctic current' *descending* to fill any vacuum that may suddenly be formed in the warm currents below it. . . . . The 'Arctic current' in *rushing down* would grate against the sides of the warm air of the under

* P. 24. † P. 57.

currents, causing '*friction*' and '*lightning*,' the sudden shock of the *impenetrable masses the* '*thunder*.'"*

"Regarding our atmosphere as a homogeneous metallic body."†

Our readers will be ready to admit that Capt. Maury has not much to fear from opponents like Mr. Armit.

We are glad, however, to be able to record a contribution to theoretical meteorology of a character very different to the foregoing. This is 'Physical Geography in its relation to the Prevailing Winds and Currents,' by Mr. J. Knox Laughton. We regret that we can only very briefly allude to its contents. Mr. Laughton gives a concise account of the existing winds, and then discusses the accepted theories of the origin of the great currents of air and water which exist on the globe. He shows that Hadley's theory of the trade winds, as developed by Dove, is insufficient to explain the facts observed. The air does not flow towards the region of highest temperature for the time being. In the old continent this district is the north of Africa and Arabia, towards which the trade wind does not blow. Secondly, he concludes that the rotation of the earth does not materially affect the direction of the currents of air, because "the friction between the air and earth is so great, that the air almost instantaneously acquires the velocity of the points of the earth to which it is transplanted," and because Dove's theory will not explain due easterly or westerly winds any more than north-westerly or south-easterly winds in the northern hemisphere (S.W. or N.E. in the southern). The laws of motion of flowing water are next described, and the action of obstacles in altering the direction of the current, and producing reverse currents or *backwaters*. After giving an account of the currents of the sea, similar to that previously given of the winds, the author concludes "that *wind*, acting not only on the surface of the sea, but, by means of intense friction, to a considerable depth, is the chief"—he will not say the only—"cause of the numerous oceanic currents."

The final theory which Mr. Laughton adopts is thus stated:—"The whole atmosphere, relatively to the surface of the earth, continually moves, or tends to move from west to east; and the prevalent local variations from that direction are either eddies, or deflections, formed in accordance with the principles which regulate the motion of fluids."

Our space will not allow of our criticizing Mr. Laughton's reasoning in detail, but we cannot omit to give him credit for having collected a most valuable series of facts from the most authentic and most recent sources, and discussed them with thorough conscientiousness. Although we may not agree with all his conclusions, we feel that he has produced a very useful and interesting work.

* P. 68. † P. 112.

9. MINERALOGY.

While the colony of Victoria has year after year been eagerly explored by many a miner in quest of its golden wealth, it is notable that the number of mineral species hitherto brought to light has been strangely incommensurate with the activity of these mining operations. In spite, however, of this poverty of materials—a poverty which is the more striking when contrasted with the prodigality of species distributed through the ore-deposits of many other mining countries—some good mineralogical work has already been done in the colony. This is due especially to the exertions of Mr. Ulrich, one of the geologists who, under Mr. Selwyn's guidance, were carefully working out the structure of the country, until the colonists were tempted, in an evil hour, to disband their staff of Geological Surveyors. Mr. Ulrich's recent observations on the minerals of Victoria have been thrown into the form of a little *brochure*,* which may be regarded as forming a sequel to an essay on a kindred subject prepared by the author for the Intercolonial Exhibition of 1867.

In the pamphlet now before us we find descriptions of three species which are entirely new to mineralogical science. One of these is a native alloy of gold and bismuth found in the Nuggetty Reef at Maldon, and hence termed *Maldonite*;† the second is a green massive mineral allied to serpentine, consisting of a hydrous silicate of alumina and sesquioxide of chromium, found in Upper Silurian rocks on the flanks of the Mount Ida range, and named *Selwynite*, in compliment to the Director of the late Geological Survey; while the third new species is *Talcosite*, a mineral which resembles talc and occurs in seams traversing the Selwynite. In addition to these newly-discovered species, many other Victorian minerals described by Mr. Ulrich merit attention, either from their crystalline forms—such as the splendid specimens of Herschelite examined several years ago by Dr. von Lang, of which some additional forms have been lately discovered—or from their peculiar mode of occurrence, such as the crystals of Struvite recently found in the guano which covers the floor of the Skipton caves in Ballarat, and appears to have been derived in great measure from the excrement of bats which resort to the caverns as a hiding-place during the day. Among gem-stones, Victoria can boast of possessing the diamond, ruby, sapphire, topaz, and garnet—some crystals of the last being notable for their singularly distorted and consequently deceptive appearance. The study of Australian gems is one which the Rev. Dr. Bleasdale has made peculiarly his own.

* 'Contributions to the Mineralogy of Victoria.' By George H. F. Ulrich, F.G.S. Melbourne, 1870. Pp. 32.

† 'Quart. Journ. Science,' October, 1869, p. 556.

Passing to another of our colonies, we find materials for mineralogical work afforded by the many meteorites which from time to time have fallen in India. One of these has lately been analyzed by Mr Waldie.* In February, 1867, a shower of about forty stones fell near Khettree in Rajpootana. Alarmed at the shower, and attributing it to the vengeance of an offended deity, the natives at once collected the stones, reduced them to a fine powder, and scattered it to the breeze. Diligent search, however, led to the discovery of a piece which luckily had escaped destruction, and it is this fragment which formed the subject of Mr. Waldie's analysis. The stone is of a light bluish-grey colour, darker in parts, and contains disseminated metallic particles and granules of a greenish-yellow colour. Its general composition was found to be as follows:—

Nickel iron	18·55
Troilite and schreibersite	5·22
Earthy matter soluble in acids	35·18
Ditto insoluble	42·36
	101·31

For eighty years a specimen has lain in the Würzburg collection, under the name of an arsenical ore. Prof. Sandberger's recent examination shows, however, that it is really a new species, which he terms *Isoclase*.† The mineral—which is said to have come from the mines of Joachimsthal, in Bohemia—crystallizes in the oblique system, and consists of a hydrous phosphate of lime having the following formula, and therefore analogous to the species Libethenite and Tagilite, among the copper phosphates: $4\,CaO.PO_5 + 5\,HO$.

Another new phosphate of lime is described by the same author under the name of *Collophane*. This is an amorphous substance found in cavities in the altered coralline rock of Sombrero, and has the following composition: $3\,CaO.PO_5 + HO$.

The energetic French chemist, M. Pisani, has published an analysis of the new Algerian mineral described by M. Flajolot as *Nadorite*—a name which has reference to the Djebel Nador, in the province of Constantine, where the mineral in question was found. While Flajolot regarded it as a compound of the oxides of lead and antimony, Pisani finds that it contains chlorine—a point of great interest, since this is the first mineral in which chlorine has been detected in a compound containing antimony. In fact, Nadorite is an antimonial Mendipite, or oxychloride of lead, and may be thus formulated:‡ $(Sb_2O_3.PbO) + PbCl$.

Rabdionite is Von Kobell's name for a new mineral from the

* 'Chemical News,' xxi., No. 551, p. 278.
† Leonhard and Bronn's 'Jahrbuch für Mineralogie,' 1870, Heft III., p. 306.
‡ 'Comptes Rendus,' Aug. 1, 1870, p. 319.

mines of Nischne Tagilsk, in the Urals.* It occurs in small dull black rods, and contains in a hydrated form the protoxides of copper, manganese, and cobalt, with the peroxides of iron and manganese. In writing the name of this species we have followed the author's mode of orthography, but the etymology of the word clearly demands the form *Rhabdionite* (ῥαβδίον, diminutive of ῥαβδος, a rod).

Hermann publishes the results of his examination of the Russian mineral *Lawrowite*,† which tend to show that it is really a diopside, coloured bright green by the presence of 4·2 per cent. of hypovanadate of lime. Accompanying this mineral, he finds a new species of analogous composition, but containing much more vanadium. This species, which he proposes to name *Vanadiolite*, may be regarded as formed of three molecules of augite associated with one of hypovanadate of lime. The same author describes, under the term *Phosphorchromite*, a Russian mineral containing chromate of lead and phosphate of copper.

A new British locality is announced for the beautiful mineral *avanturine-quartz*.‡ Mr. Traill is said to have found it in Orkney, on the S. and S.W. shores of Inganess Bay.

According to the 'Brighton Herald,' a large deposit of the subsulphate of alumina, called *Websterite*, has been recently found in Brighton during certain excavations for deep drainage.

Professor Streng's recently-published 'Mineralogical Notices'§ describe the prehnite of Harzburg, and certain pseudomorphs of calcite and asbestos, after apophyllite, also from Harzburg.

The attention of the crystallographer may be directed to Dr. Werner's paper "On the Theory of the Hexagonal System;"‖ to Dr. Klein's 'Note on some Forms of Galena;'¶ and to Herr Groth's 'Dissertation on the Topaz of certain Tin-ore Deposits, especially those of Altenberg and Schlaggenwald, in Bohemia.'**

10. MINING AND METALLURGY.

Mining.

In our Chronicles for July we noticed the proposed amalgamation of the *Mines Regulation Bill* and the *Metalliferous Mines Bill*, remarking on the unfortunate character of this attempt to legislate by one Act for two dangerous industries, differing in all their essential

* 'Journ. f. prakt. Chimie,' 1870, p. 423. † Ibid., p. 442.
‡ 'Geolog. Mag.,' Sept., 1870, p. 444.
§ Leonhard and Bronn's 'Jahrbuch,' 1870, Heft III., p. 314.
‖ Ibid., p. 290. ¶ Ibid., p. 311.
** 'Zeitschr. d. d. geolog. Gesell.,' XXII., p. 381.

Erratum in Chronicles last quarter, p. 417, line 8 from bottom: *for* "the several species," *read* "the several plagioclastic species."

points (except that they are both subterranean employments) as widely as possible from each other.

We have much pleasure in recording the fact that this amalgamated Bill has been withdrawn. The attention of the House of Commons will no doubt be called early in the next session to some system of legislation for collieries and mines. Let us hope that any Bills which may be framed, will be submitted to some persons familiar with the perils of mining, who may so organize the rules as to render them effective and beneficial.

The Colliery Inspectors have recently issued their reports of the fatal accidents and deaths in and about the coal and ironstone mines of Great Britain during the year 1869. The following is a condensed summary of their tabular statement of accidents in collieries:

	Explosions.		Falls in Mines.		In Shafts.		Miscellaneous.			
							Underground.		On Surface.	
	Accidents.	Deaths.	Accidents.	Deaths.	Accidents.	Deaths.	Accidents.	Deaths.	Accidents.	Deaths.
1. Northumberland, Cumberland, and North Durham	2	6	26	28	14	14	18	18	12	14
2. South Durham ..	1	2	30	31	6	6	24	25	13	15
3. North and East Lancashire	3	3	39	39	11	12	14	15	7	7
4. West Lancashire and North Wales	8	128	43	45	20	20	21	32	9	9
5. Yorkshire	1	1	38	41	6	7	12	15	5	5
6. Derbyshire, Nottinghamshire, Leicestershire, Warwickshire	5	6	31	31	11	12	19	22	4	7
7. North Staffordshire, Chester, Shropshire	3	7	25	25	7	7	9	10	1	1
8. South Staffordshire, Worcestershire	5	6	63	68	20	22	6	6	2	2
9. Monmouthshire, Gloucestershire, Somersetshire	6	23	37	37	..	..	5	5	3	3
10. South Wales	9	70	62	63	14	15	21	21	9	12
11. Scotland—East ..	1	1	29	30	8	8	10	10	7	9
12. Scotland—West ..	4	4	28	28	6	6	..	..	1	1
Total in Collieries ..	48	257	451	466	123	129	159	179	73	85
„ Ironstone Mines	..	..	29	29	12	12	10	10	3	3
Gross Total	48	257	480	495	135	141	169	189	76	88

Total fatal accidents .. .. 908 in 1869 .. 928 in 1868
Total deaths .. .. 1170 „ .. 1080 „

In July we stated that tin mining in our western counties had resumed a condition of high prosperity. This has, unfortunately,

been exceedingly short lived. The influence of the Continental war has led to a reduction of from 12*l.* to 15*l.* a ton in the price of tin ore, and consequently the tin miner is dispirited, and tin mines are not at all in favour with speculators.

The following were the purchases of tin ore in each month of 1869 :—

	Tons.		Tons.
January	1,203	July	1,138
February	1,291	August	1,291
March	976	September	1,144
April	1,613	October	1,178
May	1,223	November	1,279
June	1,277	December	1,112
		Total for 1869	14,725

Some interesting mining operations are now being prosecuted at a colliery belonging to the Earl of Dudley. We copy the following particulars from the 'Birmingham Gazette:'—This section of the Dudley estate has probably been the most prolific in the world so far as the actual yield of coal is concerned. It has been in work for more than a hundred years, and yet its resources hold out satisfactory promises of reward to the persevering efforts of those engaged in the present experiment. In some parts of the district on the east side of Dudley, coal is not to be found until the mine reaches a depth of 250 yards; in other parts, as in the celebrated twelve-yard-thick measure at Fox-yards, near Sedgeley, the coal crops out at the surface, and may be carted away for almost the cost of loading. In most cases the coal lies in a pretty nearly level condition, and may be worked in the ordinary way, *viz.* by a pit-shaft sunk perpendicularly into the earth, from the bottom of which "gate roads" are driven; but in some instances the coal lies in such an oblique position that to "win" it in that manner involves great cost and danger. To overcome the difficulties of getting the coal where it lies in this oblique position, the experiment under notice has been resorted to. It consists of two tunnels driven from the surface of the earth into the mine, at an angle of about thirty degrees; these tunnels are lined with substantial brickwork, and the "skips" and their contents are drawn up the inclined railway, which is laid down for the purpose, by an ordinary stationary engine fixed on the surface. The coal already got in this way is only a few yards from the surface, and it is found to be of a good serviceable quality. Similar experiments were made near Bilston twelve months ago, and the works are now in successful operation there.

The discovery of a coal of good quality in Japan is of moment. This Japanese coal has been discovered in the Takasima Colliery at Nagasaki. According to the analysis of Dr. Jas. Martin, the constituents of this coal are in the following proportions:—Carbon,

82·07; hydrogen, 5·30; oxygen, 3·35; nitrogen, 2·72; sulphur, 1·64; ash, 4·90; loss, 0·02. The samples taken from the level drives, showing a specific gravity of 1·231, are scarcely less satisfactory. On first firing up, the coal is said to give out smoke rather freely, but this soon passes off, and its deposits of soot are not more than would accrue from good English coal. The following remarks of Mr. Madden, chief engineer of Her Majesty's ship 'Ocean,' are very conclusive as to its merits:—"Keeping steam with ease at 50 lbs. pressure. Full speed for five hours with a continuous steam exhaust blast from four cylinders, being a very severe test of evaporative qualities for bituminous coal, which involves large quantities of smoke each firing for a short time, but if used in ordinary boilers, without blast and slow combustion this would be considerably reduced. I consider the two samples as tested above to be equal in general steaming properties to English North Country; and compared with Welsh, repeatedly tested under same circumstances, as shown to be best Welsh 5 cwt. = 7 cwt. Takasima."

We have recently visited the Hayle Foundry Wharf at Nine Elms to see the operation of some pneumatic stamps. The importance of introducing the utmost economy into the ore-dressing arrangements of the tin mines of Cornwall renders this invention of the highest importance. The following is a brief description of the machine:—

In the pneumatic stamp the motion is conveyed from the crank to cap and guide cross-head, on piston-rod, by an ordinary connecting-rod. Attached to its lower end is the piston-rod, and piston packed with double reverse cup-leather packings; the piston is $4\frac{1}{2}$ inches diameter, and operates freely in the upper part of a gun-metal cylinder $3\frac{1}{2}$ feet in length; attached to the bottom of this cylinder, by a socket in the usual manner, is the round stamp-head of chilled cast-iron, 9 inches diameter. The upper end of the cylinder is bored, to receive the piston, to a depth of 14 inches; the piston-rod plays air-tight through the cylinder cover, which is screwed metal to metal on the cylinder. The working barrel of cylinder is pierced with two sets of small holes, for the ingress and egress of air, discharging the air behind the piston after it has been once used as an elastic cushion. Suppose the head to be set in motion with the crank in a horizontal position, the piston being in the middle, vertically, of the working barrel of cylinder, and midway between the two sets of air-holes referred to. As the crank and attached piston rise, the air is compressed between the piston and cylinder cover, and the cylinder, with stamp-head attached, is forced upwards. When in rapid motion, the elasticity of the compressed air between the piston and cover flings the cylinder, with head, some inches above the range due to the motion of the crank; on the descent of the piston below the bottom set of holes in the

cylinder, the air is compressed in a similar manner, and the cylinder is forced down by the compressed air between the piston and cylinder bottom, until the stamp-head strikes the ore in a coffer-trough; thus, whether the quantity of ore be large or small, the blow is always effective, the only difference in the working of the machine being a shorter or longer vertical play of the cylinder and head.

The committee appointed by the North of England Institute of Mining Engineers to investigate the action of safety cages and hooks have made their report. After a most careful investigation of all the inventions which were brought before them, and they were very numerous, they have arrived at the following conclusion:—"That there are really but two different classes, namely, those which come into operation every time the chain is slackened, and those which do so only when the cage is actually falling or descending at a speed almost equal to that of a falling body. Inventions of the first class are very numerous; the second class has one sole exponent, Calow, and both depend on the action of springs (which are always subject to derangement) to initiate the grip, which intensifies itself by being drawn more and more into gear by friction on the guides. Both systems have their advantages and disadvantages; for even Calow's, although it does not wear so much as the others by being constantly in motion at the top and bottom of the pit, yet is apt to stick in the shaft if by any cause the cage receives a sudden jerk."

In conclusion the committee say:—"It must be admitted that, with every desire to see some efficient apparatus in use at every colliery to prevent the lamentable loss of life that occasionally occurs, your committee have felt an instinctive distrust of the various modes hitherto proposed for doing so, which distrust has not been altogether overcome by the investigation that has been gone into. Up to the present time there seems some element wanting to perfect these machines (some of which are excessively ingenious) and render them really reliable, and it is much to be desired that such an improvement may be arrived at speedily. With this feeling your committee cannot express an opinion as to the necessity for the adoption of any of these provisions for safety, and can only lay before you the facts they have acquired, with such deductions from statistics and observations as have presented themselves, and which it is hoped will materially assist in considering the merits of new inventions."

Papers on the Theory and Practice of Coal Mining. By George Fowler, M.E. W. M. Hutchings. London.—Mr. Fowler has read before the Institution of Civil Engineers, and other societies, papers "On the Relative Safety of different Modes of Working Coal," and on kindred subjects. These papers are now gathered together, and, reconstructed, are presented to the public in a very useful form. Each mode of working coal is carefully

described, and the author's views are given as to the relative values of the several systems. It is not practicable, did we even deem it advisable, to enter into any discussion on these questions. We must refer all of our readers who are interested in the subject of mine ventilation to the book itself, which they will find very full of useful information.

Metallurgy.

It is our duty to record such of the numerous attempts as are made from time to time to improve the make of iron and steel as may appear to possess merit. It is not a new idea to use the alkaline metals for removing deleterious ingredients from iron; but we are not aware that it has hitherto been proposed, as is now done by Girard and Poulain, to force the vapour of potassium or sodium through the molten metal. They propose to saturate the fuel with carbonate of soda, and dry it, or to mix common salt with the fluxing materials. These inventors, however, appear to place most confidence in a process for blowing those vapours mixed with moist air, or moist carbonic oxide, through the melted metal in a Bessemer converter. Pure iron or steel is said to be thus obtainable at pleasure. If experience proves this, we shall soon hear more of this process.

The continually-increasing demand for high-class pig-iron and iron ores, caused by the extension of the Bessemer process, has brought into notice the red hematite and magnetic ores of Norway as a possible source of supply for the Continent. According to a statement published in the 'Berggeist,' a paper representing the metallurgical interests of Westphalia and the Rhine provinces, it has recently been suggested to employ the magnetic ores raised in the neighbourhood of Arendal for the production of Bessemer iron on the spot, the total output of which the mines are capable being estimated at 50,000 tons of 40 per cent. annually, which it is proposed to smelt in two moderate-sized furnaces with coke made on the spot from washed English small coal. Whether such a proposal is likely to be commercially successful may be doubted; but the point is in so far of interest as showing how completely iron making is now governed by the item of cheap fuel; the making of charcoal pig-iron even in a thickly-wooded country like Norway being nearly at an end, for out of fifteen blast-furnaces in the southern part of the country only five are now in blast, the cost of production of pig-iron being nearly 6*l.* per ton, owing to the high price of charcoal. On the system proposed, the cost of No. 1 grey Bessemer iron is computed at 68*s.* 6*d.* per ton, which, could it be realized, would leave a fair margin on the selling price of hematite pig-iron in our north-eastern ports.

The question of the exact nature of the changes involved in the conversion of pig-iron into steel in the Bessemer process, or rather of the composition of the pig-metal employed, is still a matter of great uncertainty. That sulphur, phosphorus, and copper are in no degree removed during the process, and that consequently these impurities must be absent from the metal treated, is proved by all the analytical investigations made in this country as well as in Sweden and Austria. As regards the question of silicon, Professor Jordan, of Paris, has recently pointed out, in a memoir published in the 'Revue Universelle,' the probability that the enormous heat developed in the process is mainly due to the combustion of this element, because the whole of the heat produced by the burning of silicon to silica, of silicate of protoxide of iron in the slag, and the subsequent formation is entirely retained in the metallic bath, while that produced in the combustion of the carbon to carbonic oxide is in great part carried out in the current of flame and heated gases issuing from the mouth of the converter. The exactitude of this view cannot of course be positively demonstrated, because neither the calorific power of silicon nor its specific heat has yet been determined. If, however, we assume with Professor Jordan, which is not improbable, that these factors are the same for silicon as for carbon, it can be shown that in the conversion of a pig-iron containing 4·25 per cent. of carbon and 2 per cent. of silicon that the amount of heat developed by the combustion of the latter element is more than six times as much as that obtained from the former. In proof of this statement it is asserted that the Bessemer process could only be successfully carried out at Terrenoire in France when the metal was run direct from the blast-furnace to the converters, the small proportion of silicon, about $1\frac{1}{2}$ per cent., present being not sufficient to allow it to be cast into pigs and remelted, as is usually done. The dark grey No. 1 Bessemer pig-iron produced in Cumberland and Lancashire contains generally from 2·6 to 2·7 per cent. of silicon. It appears to be probable, however, that when too much silicon is present, or rather when its proportion as compared with that of the carbon is too high, it may not be entirely removed in the blowing.

The separation of sulphur and phosphorus from iron has long been a problem of much interest, especially so since the introduction of the Bessemer process. At the Working Men's International Exhibition at the Agricultural Hall, London, is a display of specimens of iron obtained, by a process invented by Sir Antonio Brady, from some of that dockyard refuse irreverently described as "Seely's pigs," and which has been the subject of discussion both in Parliament and by the press. These pigs were of different qualities, but were all largely contaminated with phosphorus and sulphur, and were supposed to be of little or no value. The presence of phos-

phorus renders iron brittle when it is hot; the presence of sulphur renders it brittle when it is cold. The pigs containing both were worth in the market about 2*l.* 5*s.* a ton. By Sir Antonio's process the sulphur and the phosphorus is said to be extracted at a cost of about 35*s.* a ton, and the residual iron is described as "superb." One of the pieces exhibited is stated to have been beaten cold to the thinness of writing paper at one end, drawn to a point at the other, and then twisted by hand eight turns in an inch at a single heating. Massive bars are said to have been beaten cold until the surfaces on each side of the bend came into perfect contact, and a plate six inches wide and half an inch thick to have been beaten till its edges were in contact, the flat surface remaining horizontal. In neither case was there any trace of a flaw, either at the convexity of the curve, where the metal was stretched, or at the concavity, where it was compressed. Holes in a thick plate are labelled as having been enlarged by driving cones into them, and, in a word, the iron is described as having been knocked about in every possible way. At a very low estimate it is affirmed to be worth 14*l.* a ton, and as there is plenty of the raw material to be had, the profit of the invention seems likely to be great.

A remarkable steel casting was made recently at the works of Messrs. Thomas Firth and Sons, Sheffield, which deserves a record. This casting is to form the shaft of the screw of the Dublin Steam-Packet Company's vessel 'Munster,' and is about 15 feet in length by nearly 4 feet in diameter, and weighs over fifteen tons. This is one of the largest blocks of steel ever cast in this country.

The work of melting commenced about eight o'clock, in no fewer than *five hundred and forty-four* crucibles, each containing 64 lbs.—the total quantity of steel being 34,816 lbs. At half-past twelve the work of casting began, and was rapidly completed, by the joint and perfectly organized action of 300 men. This metallurgical operation was a perfect triumph of mechanical skill.

The enormous difficulty and expense caused by the ever-accumulating mountains of slag produced by iron furnaces worked on the modern scale, often amounting to as much as 60 tons per furnace per day, has led to different proposals for utilizing these unpleasant *ejecta*, and we remember certain glowing descriptions of valuable results to be got by converting the despised slags into materials rivalling the finest porphyries and other ornamental rocks. The less ambitious but more practical plan of using them as paving stones has been for some time past under trial in Brussels, and, according to Kennis, with such success that they are to be employed generally in the repavement of that city. The process employed is simply that of allowing the cinder to run from the furnaces into an excavation sufficiently large to contain the whole daily yield of several furnaces, and the cooling is retarded by covering the surface

with earth when the pit is filled. When cold the mass is found to leave a widely-radiated structure, recalling that of natural volcanic rocks, and the texture is that of a finely crystalline or granular porphyry, having a mean specific gravity of 2·77. The surface is said to wear in such a manner as not to become slippery under traffic, and the cost to be 20 per cent. less than that of ordinary stone paving. It is very much to be desired that experiments of this character should be carried out in the only district in this country where blast-furnace slags are used as a road material to any great extent, *viz.* in Northamptonshire, where, according to the present method, the general character of the roads may be represented by a series of parallel ruts filled with broken glass, owing to the slag used being cooled in small masses, producing a vitreous substance unfitted for road making, but which is used owing to the difficulty of obtaining natural stone for the purpose.

A new process of casting metals has lately been attracting considerable attention. In July a number of gentlemen met at the Lancashire Engineering and Compression Casting Works, at St. Helens Junction, to witness the new process of casting in brass and iron chased and embossed work of the most elaborate description. The process, which was here for the first time exhibited in England, is an American invention, and its utility was shown to consist in this—that any design, whether in high or low relief, chased on metal of any required pattern or shape, whether flat as a door-plate or round as a vase, can be produced by castings from it *ad infinitum*, and each casting will show upon it all the sharpness and beauty of the original chasing. Moulds are made with a preparation of fine clay from the articles to be reproduced. The making of one of these moulds takes a person from five to ten minutes. The moulds have then to stand twenty-four hours exposed to dry air, after which they are baked in a furnace for eight hours. These clay moulds, into which the metal is afterwards poured, are, to all intents and purposes, encaustic tiles. The moulds are placed in a box, and the air is extracted from them so as to form a vacuum, after which the molten metal is forced into them, and in this way, in ten minutes, a casting can be completed. When the casting is taken out, the design, however intricate, is found to be perfectly represented, with the exception of removing a slight surface of clay from it, which can be done in half an hour, and the article is then ready to be sent to the bronzer, instead of having to be kept in the chaser's hands. In this way an enormous amount of cost and labour on ornamental articles in metal is saved.

A new process for refining and desilvering lead has been introduced by Gustave Luce, Son, and Bozan, of Marseilles. The invention consists in the application of steam. For this purpose the crude argentiferous lead is melted down in a vessel heated by a

fire, and provided at its lower end with a spout, closed with a slide, through which, when the lead is melted, it is caused to flow down into a lower vessel or vat, heated only at times directly by a special fire, and at other times by the waste heat from the fire of the upper vessel. When the lower vessel is full, steam is introduced through a central pipe, leading down to near the bottom of the vessel, where it is provided with a cock turned by a rod from above, and with a disc, for the purpose of dividing the steam as it enters. The steam, in passing up through the molten lead, effectually oxidizes all impurities, which then rise in the form of scum to the top of the metal, whence they are removed. The introduction of the steam at the same time produces a violent ebullition of the lead, causing it to crystallize; and when this crystallization has taken place to a sufficient extent the introduction of steam is stopped by closing the cock on the steam-pipe, and the remaining liquid portion of the lead, in which the greater proportion of the silver will be found concentrated, is run off through one or more spouts into troughs turning on pivots for conducting the lead into a series of ingot moulds. During this time a fresh charge of lead, containing a percentage of silver approximating to that of the crystals in the lower vessel, has been melted down in the upper vessel, and is run into the lower vessel as soon as all the liquid portion has been removed therefrom. Steam is then again introduced, effecting a further purification and separation of silver, and this process is continued until, by the repeated crystallization, one part of the lead is rendered comparatively free from silver, to be used as merchant lead, while the lead run off is sufficiently rich in silver for the cupelling process. The duration of each operation for twelve or thirteen tons of argentiferous lead is about from two and a half to three hours.

The Iron and Steel Institute, whose first provincial meeting was held at Middlesbrough last year, has just held (September, 1870) another such meeting at Merthyr Tydfil, the chief seat of the coal, iron, and steel industries of South Wales. The formal business meetings of the Institute extended over two days, and other two days were devoted to the inspection of the iron and steel works at Swansea and Ebbw Vale. Although the Institute has not yet been in existence two years, there are already upwards of 350 members enrolled, a large proportion of whom were present at Merthyr, notwithstanding its great distance from the other principal seats of the iron-trade, and the difficulty attending the means of reaching it. At the meeting just held, the Duke of Devonshire presided, and Mr. Henry Bessemer was elected to the presidentship for the ensuing two years. The Council of the Institute have resolved to discontinue the publication of the 'Transactions of the Institute,' and to issue instead a quarterly journal devoted to the

science and practice of the iron and steel manufacture, both at home and abroad. The foreign editorship of the journal is to be conducted by Mr. David Forbes. Several very interesting and important papers were read and discussed at the Merthyr meeting. We can only find space to indicate the subjects upon which they treated.

I. "The Geological Features of the South Wales Coal-field." By Mr. William Adams, Cardiff. In this paper the extent of the coal supply of South Wales was put down at 36,000,000,000 tons, even after making a very liberal allowance for faults, waste, loss in working, &c.

II. "On Pumping and Winding Machinery at the Castle Pit, Cyfarthfa." By G. C. Pearce, Cyfarthfa Iron-works. This was a short paper describing some recently-erected machinery of a superior character, and which was carefully inspected in operation by the members.

III. "On the Condition of Carbon and Silicon in Iron and Steel." By Mr. Geo. J. Snelus, Associate of the Royal School of Mines. This was the longest and most elaborate paper read at the meeting. In it the author showed that he had struck out a new path, a method, or rather methods, of mechanically separating the carbon and silicon contained in iron and steel, which will doubtless prove to be a valuable supplement to the ordinary methods of chemical research.

IV. "On a New Form of Pyrometer." By Mr. C. W. Siemens, C.E., F.R.S. The author described several kinds of pyrometers, and then described and exhibited one constructed upon a plan involved in the principle that the pure metals have the property of offering an increasing resistance to the passage of an electrical current with increase of temperature.

V. "On the Efficiency and Durability of Plain Cylindrical Steam-Boilers." By Mr. Jeremiah Head, Middlesbrough. The author of this paper gave an account of a new method of suspending or supporting plain cylindrical boilers so as to prevent explosions. Out of nearly 18,000 boilers on the books of the boiler insurance companies, 22·7 per cent. are of this sort, thus showing that they are much in request. A method of ensuring their safety is therefore a thing much to be desired.

Other two papers were set down for reading, but there was no time left for them. One of them was by Mr. F. Kohn, C.E., and the subject was, "On the Production of Alloys of Iron and Manganese, and on their Application to the Manufacture of Steel."

11. PHYSICS.

LIGHT.—A new substance possessing fluorescent properties in a very high degree has been prepared by Professor A. H. Church from the *Cyclopia vogellii*, one of the plants used by the African Boers for tea. It possesses acid properties, and the discoverer calls it cyclopic acid. Its action on light is best seen when a crystal or two of the new body is dropped into a solution of caustic soda and viewed in sunlight. An intense greenish-yellow fluorescence is perceived at first, but disappears in the course of some hours.

A new artificial light which has recently been successfully experimented with, called the Philipp carbo-oxygen lamp, and its recent trial at Cologne, was such as to win approval on every hand. The light is generated by the combustion of a liquid chemical compound in a current of oxygen, arrangements for the purpose being constructed in a suitable lamp. The gas is derived from the atmosphere either by chemical or mechanical means; the chemical methods being to absorb the oxygen of the air with chloride of copper (Mallett's method), or with manganate of potash (Tessie du Mothay's method), while the mechanical mode is that of utilizing the different degrees of solubility of nitrogen and oxygen in water or other liquids. By compressing atmospheric air into receivers filled with water, a portion of the nitrogen is taken up by the water, while the oxygen remains insoluble in the water; the air thus containing a goodly proportion of oxygen is forced into a second reservoir of water, where a further amount of nitrogen is absorbed, and after the operation has been repeated seven or eight times, an atmosphere is obtained containing 97 per cent. of oxygen. The nitrogen which has been separated is made use of in a well-constructed apparatus as an auxiliary to the motive force. Experiments have established the fact that a flame fed with air containing 53 per cent. of oxygen yields a light equal in brilliancy to that obtained with pure oxygen, and with diluted oxygen of this kind the Philipp flame has a brilliancy of 90 to 100 candles, or ten times that of an ordinary gas jet. The light is of a bluish-white, resembling very much that of electricity or burning magnesium. The liquid employed consists of liquid hydrocarbons very rich in carbon; it costs but little, burns economically, and can be employed only in this particular direction. The flame is made to assume the form of a star, and any heating of the wick-holder thereby prevented; if of the size and power above mentioned, the quantity of gas consumed is $5\frac{1}{2}$ cubic feet per hour. As to the lamp, no special attention is necessary beyond that of filling it with liquid, as the wick is of a very durable nature, and needs no trimming.

An optically-neutral sugar has been prepared by E. J. Maumené. He mixes equal parts of pure sugar-candy and neutral nitrate of silver, both previously dissolved in water, and evaporates the mixture upon a water-bath. He states that neither at 100°, nor even at 140°, any decomposition ensues or any reduction of silver takes place, provided the sugar be free from inverted sugar. The sugar, rendered syrupy by the process described, is optically neutral. The silver-salt is separated from the sugar by means of pure chloride of calcium, and the nitrate of lime is separated from the sugar by the addition of alcohol and placing this mixture under a bell-jar along with quick-lime. In this manner, by slow concentration, two layers of different specific gravity are formed: the upper being an alcoholic solution of nitrate of lime, the lower a viscous saccharine liquid. The former is poured off, and, by a slight washing with cold distilled water, the thick sugar solution is freed from any adhering nitrate of lime. The sugar obtained does not crystallize.

In a lengthy paper on the optical properties of benzyl, and of some substances belonging to the camphor groups, in the crystalline state and in solution, M. des Cloizeaux describes a series of experiments, the chief results of which are that benzyl and periodate of soda possess, when in the solid crystalline state, strongly-marked rotatory powers, and are devoid thereof in the state of solution. Quartz, chlorate, and bromate of soda act the same. Sulphate of strychnia possesses rotatory powers in crystals as well as in solution, while ordinary camphor, patchouli camphor, camphor of oil of mint, Borneo camphor, tere camphor, and monchlorhydrate of turpentine possess rotatory power when in solution, but not in the crystalline state.

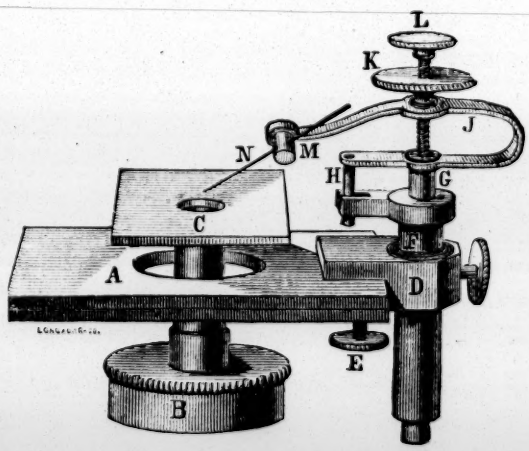
O. Loew has found that when aqueous sulphurous acid is exposed in sealed tubes to the action of sunlight, it is gradually reduced to sulphur, but the oxygen is not liberated, another part of the acid having been oxidized by it to sulphuric acid.

According to J. Girard, who has made several voyages on the Mediterranean Sea, its peculiar colour, ranging from pale blue through all shades of that colour to black (*viz.* when seen from a ship's deck), is entirely due to the mode of reflexion of the sun's rays according to the lower or higher position of that luminary above the horizon, so that at mornings and evenings, when the rays fall more obliquely and pass therefore through a larger bulk of water the colour is deepest, provided it be at such distances from the shore that the depth of the sea is sufficiently great.

At one of the recent meetings of the Franklin Institute, Professor Morton exhibited in the lantern some pictures on gelatine prepared in a manner devised by Mr. Holman. For this purpose

a sheet of gelatine, such as is used for tracing by engravers, was securely fixed over an engraving, and with a sharp steel point (made by grinding down the end of a small round file), the lines of the original traced pretty deeply on the transparent substance. Lead-pencil or crayon dust was then lightly rubbed in with the finger, and the picture was at once ready for use. A number of such drawings could be easily carried between the leaves of a book, each in succession being held in a frame or cell made of two plates of glass separated by a frame of thin card or three edges, and united by paper or muslin pasted around the same edges. The effect of these drawings in the lantern was excellent, and their ease of production very great.

A most valuable adjunct to the microscope has been made by Mr. J. Zentmayer. It is a mechanical finger, which in the study of diatoms forms a substitute for the clumsy fingers of the human hand, to do the delicate work of picking up rare and valuable diatoms detected by the microscope, and to transfer them to a slide for preservation. The instrument may be readily understood on reference to the accompanying cut.



A is the top plate of the mechanical stage; the circular plate is omitted. The cap B is fitted to the lower body below the stage, into which cap the new sub-stage C is fastened by a narrow tube, wide enough to admit illumination from the mirror. As the lower body is movable up and down by a rack, another movement is gained which is necessary to accomplish the result. The difference of the size of the aperture of the stage and the diameter of the tube which connects the sub-stage with the cap A is equal to the movement of the mechanical stage, and this is found more than sufficient. D is the clamp by which the finger is attached to the stage by means of the screw E. A steel cylinder, G, is nicely fitted into the top and bottom of the tube F, leaving room inside for a light spring to press the steel cylinder upwards. To prevent turning, the spring J is provided at H with a steel pin, accurately fitted into the fork at the top of the tube F. By turning the nut K the spring J is elevated and depressed, giving nice adjustment to the needle N in case the finger is to be attached to a microscope not having rack movement to the cap B, to bring the end of the hair and the object in close approximation. The end of the spring J forms a little ring, with

a screw cut inside into which a cork M is screwed to receive a needle N, to which a hair is fastened by wrapping gum paper around. Turning the cork facilitates the adjustment of the hair to the proper inclination. A slight pressure on the button L brings down the hair, and the spring inside of F instantly lifts it again when the pressure is removed. The tube F turns in the clamp D in order to adjust the hair and cork more conveniently, and when brought back again it is tightened by a set screw. Complicated as it may appear, only one movement is added to the microscope stand by this instrument, the one, namely, which gives the vertical motion. When the apparatus is to be used, the material to select from is placed on the sub-stage C and focussed, then the point of the hair is approximately brought over the selected object by means of the stage movements and turning of D; this brings the hair nearly in focus too, because it is almost in the same plane with the object. Next adjust the hair precisely over the selected shell, press down the button L, and the shell will adhere to the hair. Now remove the slide with the material and substitute a glass slide moistened by breathing on it, and having brought it in proper position briskly dip down the button L again and the shell will be deposited on the glass slide. If the mechanical stage has a graduated indicator, the finger may be moved along regularly and shells may be placed at equal distances in lines. After the cover glass is carefully placed over it, Canada balsam may be run in by capillary attraction without disturbing the position of the shells.

HEAT.—Dr. J. D. Boeke, Teacher of Chemistry at the Hoogere, Burgerschool at Alkmaar, opposes the statement of Mr. Loew that ozone is formed by rapid combustion. On repeating Mr. Loew's experiment with this slight modification, that a stream of *oxygen* instead of *air* was blown through the luminous flame of a Bunsen's burner into the mouth of a glass balloon, he really found that the air in the balloon had assumed a peculiar odour, and the property of colouring blue a mixture of starch paste and of potassium. But it appears that both changes are the result of the formation of a compound of *oxygen and nitrogen* (probably dinitric trioxide or nitric dioxide), *not* from the formation of *ozone*, as Mr. Loew asserts. So when Mr. Loew declares that he was able to "identify the formation of *ozone* by its intense odour and the common tests," he was somewhat rash in this conclusion. Still Mr. Loew's experiment is a very interesting and easy one, and will soon take its due place in the series of lecture-experiments intended to elucidate the complex phenomena of combustion.

H. Sainte Claire-Deville relates at great length a series of experiments which may be summarized as follows:—Perfectly pure iron kept at temperatures varying from 150°–1600°, is treated with

vapour of water of a known tension and temperature. Under these conditions results are obtained which prove that the decomposition of vapour of water by iron while red-hot is rigorously subject to all the laws which govern the tension of saturated vapours.

M. E. Cappel has published a lengthy paper on the influence of the temperature on the sensitiveness and delicacy of spectrum reactions. The main result is, that the temperature most suitable for the spectrum analysis of the alkalies is that of the oxyhydrogen flame, and for the rest of the metals the heat of the electric spark. The higher the temperature the more distinct the reactions.

In some observations on the batswing-burner flame, Dr. A. Baudrimont states that the flame consists of two distinct portions, one of which (the interior) has a comparatively low temperature while it is surrounded by a luminous envelope, the temperature of which exceeds that of molten platinum. Indeed the author found that a platinum wire $\frac{1}{10}$th mm. thick, when properly placed in this flame, fused immediately.

General Morin has experimented at the Conservatoire des Arts et Métiers on some fire-clay stoves; the results are said to be highly satisfactory. The useful effect of heat given off by the fuel amounts to 93 per cent. The air in the rooms where these stoves were placed was not at all vitiated so as to incommode those present, notwithstanding the interior of the stoves became thoroughly red-hot. The author says that, taking all in all, these stoves, when suitably connected with flues, will afford a cheap and in every respect wholesome mode of heating apartments.

A new material for the manufacture of crucibles is described by M. J. Desnoyers. The substance known as gaize, or *pierre morte*, is a mineral largely met with in the departments of the Ardennes, where it forms a deposit of some 100 mètres thickness. Its specific gravity is 1·48. It is on being dug up quite soft, so that it can be cut with a knife, but becomes hard on drying and very hard when exposed to red-heat, whereby its specific gravity is reduced to 1·44. This material is essentially a substance capable of withstanding high temperatures; and the author exhibits crucibles made from the gaize which have been used successfully for melting iron. Dr. La Salvelat, the celebrated chemist of the Imperial Porcelain Works at Sèvres, states that layers of similar material exist in the central parts of France, and that these minerals are of great value for the construction of blast and other furnaces.

By the term "rochage," H. Caron understands a peculiar production of sparks, best seen when molten cast-iron is run off from the blast furnace into moulds. In a lengthy paper the author describes a series of experiments undertaken with the view to prove that since steel and cast-iron, when molten in an atmosphere of

hydrogen or oxide of carbon, never emit sparks, the production of the latter cannot be due to an evolution of reducing gas absorbed during the fusion, but is due, according to the author, to the formation of oxide of iron at the moment the molten metal comes in contact with air. This curious phenomenon is well known to those engaged at blast furnaces. The sparks are known by the workmen as "jumpers," and their presence is usually held to indicate an approximation to white iron. These sparks are absent during the running of grey iron from the furnace, and only begin to make their appearance when the iron is about No. 4, the usual degree of greyness preferred in South Staffordshire for puddling. The sparks are best observed during the running of white iron from the furnace, especially if the molten metal is not very fluid, at which times a vast number are produced, particularly in the channel; and sometimes after the pigs have "set," little jets of sparks are continuously discharged for many minutes, which discharge is accompanied by a hissing sound. M. Caron's view may probably be correct, but a correspondent of the 'Chemical News,' who signs his name T. B., says that he is inclined to attribute the production of these sparks to the combustion of carbon and not of iron, as there is an entire absence of the peculiar scintillations displayed by burning iron.

A very striking mode of demonstration in the lecture-room that burning bodies increase in weight has been contrived by H. Kolbe. A glass rod is fastened in a horizontal position to one arm of a balance. Upon this is fastened a glass cylinder in which a candle is burnt, connected with which, by a glass tube, there is a V-tube for condensing the vapour, a flask filled with lime-water for carbonic anhydride, and two more V-tubes containing soda-lime. The last are connected by an india-rubber tube with a Bunsen's pump, by which a steady current of air is drawn through the apparatus. The beam is first counterpoised; as the candle burns away the arm of the balance to which it is attached sinks down until its progress is arrested by the table.

Mr. W. T. Suffolk, the well-known microscopist, has experimented during a pedestrian tour on the most advantageous methods of boiling water, and has come to the conclusion that the very best arrangement is an "Etna" of French construction made of very thin copper, electro-plated, and weighing, with a store of 6 oz. of spirit, 1½ lb. The time occupied in boiling half a pint of water is from seven to ten minutes, and the consumption of spirit about two fluid drachms. The apparatus requires a perfectly calm atmosphere for its proper action; this may be secured by building a small *cromlech* of flat stones, which are always at hand in hilly countries, and with the help of a large handkerchief as a further protection against the wind, no difficulty will be found in securing

efficient performance; other contrivances will suggest themselves where stones are not procurable. Although it would seem that alcohol is consumed to a disadvantage without a wick, yet practically the "Etna" boils water with a smaller consumption of spirit than any contrivance yet tried, a good argand lamp requiring at least half an ounce to do the same work as the Etna. The Russian blast lamp is still more wasteful, consuming nearly 2 ounces. The superior economy of the Etna is attributed to the low temperature of the wickless flame and the manner in which the boiler is wrapped in the fire, no more heat being supplied than can be taken up by so bad a conductor as water. The defect of all lamps giving an intense flame being that heat is wasted by being supplied too quickly, so that the apparently feeble fire in the gutter of the Etna is more efficient than the heat of powerful lamps, as well as more economical; the latter quality is very important to the pedestrian, to whom every ounce of weight is a consideration.

P. Lewald, referring to the phenomenon first observed by Dr. Fritsche, says it is not at all a correct statement that the blocks of tin exposed to a cold of $-35°$ should alter their state of aggregation from that cause; the real cause is that the blocks of tin usually of 250 cubic inches capacity are cast in iron moulds, and as a consequence thereof the tin contracts unequally, and so as to leave in the inside of the blocks cavities often so large as to occupy 40 cubic inches. These hollows are lined by a crystallized metal at a high degree of tension. The tin at St. Petersburgh was laying heaped block upon block, and the effect of the cold was simply a remote cause to what took place, the weight of the blocks of metal placed on each other being such as to produce necessarily a pressure too great to be borne by the undermost blocks. The author says, if tin is molten and allowed to cool, so as to shrink uniformly, no cold, even of $-40°$ or less, will have the effect observed in the locality alluded to.

L. Cailletet has studied the variation of compression of air and hydrogen between 1 and 800 atmospheres. Up to 80 atmospheres' pressure, air is more compressed than it should be if it followed the law of Mariotte; and at 680 atmospheres' pressure it only occupies two-thirds of the space which it ought to do theoretically. The method by which the author is enabled to measure the volumes occupied by a gas in an opaque apparatus is very simple. The glass tube is enclosed in an iron one; the former, containing the gas, is lightly gilt. The mercury which serves for the transmission of pressure, whitens the gold, leaving a well-defined mark on it after the pressure ceases.

Electricity.—In a letter to M. Dumas, Professor de la Rive states that he has just finished a series of experiments on the mag-

netic rotatory power of liquids, the results of which will be shortly published. The first portion of this work is devoted to the description of the apparatus and processes of experimentation; the second part contains the results of the determination of the magnetic rotatory power of some liquids. As a curious anomaly the author mentions that taking water as unit, the coefficient of the magnetic rotatory power of monohydrated sulphuric acid is 0·750, and that coefficient is, for liquid anhydrous sulphurous acid, equal to 1·240 at a temperature of 12°. The third part of this work is devoted to the study of the influence of the temperature on the magnetic rotatory power. In the fourth part, the author gives the results of his investigations of the magnetic rotatory power of a mixture of two liquids as compared with that each of these liquids possesses separately. The fifth part contains the results obtained by experimenting with two isomeric liquids.

In some experimental researches on the length of duration of the electric spark, MM. Lucas and Cazin employ two transparent discs placed upon the same axis. One of these discs is a fixture, while a more or less rapid rotatory motion can be imparted to the other. Upon both discs are painted the same number of opaque stripes in the direction of the radius. When, therefore, an electric spark is observed through these discs, a certain amount of speed having been imparted to the movable one (the apparatus being placed in a darkened room), it is clear that by the light emitted by the spark a certain number of coincidences of the movable and fixed stripes may be observed, and these coincidences may serve to calculate the period of duration of the spark.

Dr. Demayes describes at length an apparatus constructed by him, which appears to be an improvement on Siemens' electro-magnetic apparatus; while making from 250 to 280 revolutions a minute, the lifting power of the magnet is 70 kilos., and under similar conditions a platinum wire, 0·8 mm. thick and 20 centim. long was rendered red-hot, and iron wire of the same thickness fused; the machine produces per second of time half a cubic centimètre of gas by the decomposition of water.

In a recent instalment of his researches on electro-capillary action, which have occupied M. Becquerel for a series of years, he announces the artificial formation of the oxychloride of copper in crystalline state, and exactly similar to that found in the copper mines of Peru and Chili, and known as atacamite. This formation has taken no less than fifteen years.

Mr. E. W. Blake, jun., has described a method of producing by the electric spark figures similar to those of Lichtenberg. The method consists in throwing the discharge upon the surface of a fusible non-conducting body. If the body be near its fusing-point

the figure appears at once; if cold, a latent image exists, which may be developed by heat. The non-conducting surface is prepared by coating a plate of metal with an even film of pitch. Pieces of sheet tin, 3 inches square, coated with films of pitch of a thickness varying between 0·01 and 0·02 inch were used; the pitch was the ordinary article of commerce freed from sand, &c., by being melted and strained through a muslin bag. The author gives cuts of the figures as produced by frictional electricity and the induction coil.

Metallic iron, as obtained by the electric current, has been examined by C. Collas. He employs a weak solution of chloride of iron, which is decomposed by the aid of a Bunsen battery; perfectly pure iron is thus obtained, which is very friable, highly oxidizable, especially when moisture is present. When this iron in the state of fine powder is poured in a bottle when the atmosphere is very moist, the iron is instantaneously oxidized, water decomposed, and the evolution of hydrogen causes the bursting of the bottle.

A new method of copper extraction and its separation from other metals is published by Mr. J. Elkington. The principle consists in applying electricity for dissolving the copper contained in the crude metal obtained by the usual smelting methods, and for depositing that metal galvanically upon plates of copper, causing the other foreign metals to fall to the bottom of the vessels in which the operations take place; copper containing very small quantities of silver may be advantageously treated thus for the recovery of the last-named metal.

An improvement in galvanic batteries has been devised by Mr. W. Poole Levison, of Cambridge, Mass. While making use of a small bichromate of potash battery he discovered that the addition of nitric acid to the mixture of potassic bichromate and sulphuric acid contained in its porous cups, conferred upon it the virtue of *steadiness* without involving the evolution of annoying fumes. For over two months during last summer the author had in almost constant action a combination of twenty-three large Bunsen cells charged with dilute sulphuric acid and the triple mixture mentioned, and "set up" openly upon the floor of the room. Not only did he work about it with perfect comfort, but left choice brass instruments in its immediate neighbourhood with impunity. Its energy never fluctuated, but after remaining for some time steady declined, precisely as if the electro-negative plates were bathed in nitric acid only. To a cooled mixture of potassic bichromate solution and sulphuric acid (perhaps preferably in atomic proportions) add *nitric* acid. The proportion of nitric acid may be greatly varied, as its office is merely to transfer oxygen.

A research on the best methods of tinning of iron without the

aid of heat has been carried out by J. B. A. Daubié. The chief point of interest is that the tinning of iron in the cold cannot succeed at all, unless the bath used for that purpose contains in solution or suspended an organic substance like starch or glucose, although no precise scientific explanation of this indispensable condition has been hitherto given. The author employs the following bath: To 100 litres of water are added 3 kilos. of rye meal; this mixture is boiled for half an hour, and next filtered through cloth. To the clear but thickish liquid are added 106 kilos. of pyro-phosphate of soda, 17 kilos. of protochloride of tin, 100 to 120 grammes of sulphuric acid; this liquid is placed in well-made wooden troughs, and serves more especially for the tinning of iron and steel wire for the use of carding-machines. When instead of the two salts of tin just named cyanide of silver and cyanide of potassium are taken, the iron is perfectly silvered.

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12. ZOOLOGY AND MORPHOLOGY.

The Zoological Position of the Brachiopoda.—Leuckart, Haeckel, and Gegenbauer do not include the Polyzoa among the Mollusca, as is done by Huxley, but class them as also the Tunicata among the great heterogeneous group of Vermes. Mr. Morse, an American naturalist, who has devoted much study to the Molluscoida, proposes to turn over the Brachiopoda into the same position. In doing so he unconsciously meets an argument advanced in favour of the retention of the Polyzoa among Mollusca by Professor Rolleston, *viz.* that they present close affinities to the Brachiopoda, especially to the larval Brachiopod described by Fritz Müller. Mr. Morse has by perseverance obtained the great advantage of studying living specimens of *Lingula*, a species of which he obtained in quantity on the North Carolina coast. He compares the setæ which fringe the mouth of *Lingula* to those of Annelids (in this he is probably misled), the lophophor with its cirrhi to the cephalic appendages of tubicolous worms, the oviducts with their trumpet-shaped openings to the funnel-like oviducts of many worms; the embryo of *Thecidium*, with its four segments and eye-spots, is adduced, as also the embryo of *Discina*, which, according to Fritz Müller, has projecting bristles like the temporary bristles of some Annelid-larvæ. Mr. Morse says it is a startling discovery that the vascular fluid of *Lingula* is red, and seems to think that this colour gives this Brachiopod some affinity to worms. It is, however, not at all surprising, though *Lingula* is an interesting addition to the category of invertebrata with red blood, including as it does already the molluscs *Planorbis* and *Arca*. Probably

the coloration is due to Hæmoglobin as in the cases of Molluscs, Insects, Crustacea, and Vermes with red blood, investigated by Mr. Ray Lankester. Mr. Morse's proposition to classify Brachiopoda with Vermes deserves full consideration, but we shall look for some solid reasons in the memoir which he promises on the subject.

New Sponges.—Sponges continue to occupy a great deal the attention of naturalists. Dr. Perceval Wright, Mr. Carter, Mr. Charles Stewart, and others, have lately described new genera and species. Mr. W. S. Kent, of the British Museum, who two months since made an expedition to the coasts of Portugal in the yacht of Mr. Marshall Hall, has described three new species (two belonging to new genera) of that very important and interesting group, the silicious sponges or Vitrea of Professor Wyville Thomson. The Vitrea are represented by the notorious *Hyalonema*, or glass-rope sponge; by *Euplectella*, the beautiful lace-sponge; and by Professor Thomson's new genus, *Holtenia*. Mr. Kent would recognize Dr. J. E. Gray's division of the Corallispongia in preference to that of Vitrea proposed by Professor Wyville Thomson. In describing a new species allied to that author's *Holtenia Carpenteri*, he points out that the genus *Holtenia* must give place to *Pheronema*, previously proposed by that most distinguished of American naturalists, Dr. Leidy, of Philadelphia. There appears to be no doubt that the sponge described under this name by Dr. Leidy is generically identical with Wyville Thomson's subsequently described *Holtenia*. Mr. Kent's new species is called *Pheronema Grayi*, and was obtained by him in the deep sea off the coast of Portugal. Two other interesting vitreous sponges were also detected, and have been fully described by Mr. Kent. The Royal Society assisted Mr. Kent in the outlay necessary for dredging apparatus, &c., and these new sponges are among the first of the fruits of his voyage which he has made known. The Society has done well to entrust some of its funds to this promising naturalist; and zoological science is much indebted to Mr. Marshall Hall for using his yacht for its advancement.

Bathybius and the Coccoliths.—The organism which Professor Huxley described two years ago as being so widely spread in the ooze of the ocean bottom, consisting of a simple ramified network of protoplasm, has been recognized and fully established by no less an authority than Professor Haeckel, of Jena. Professor Haeckel gives figures of the protoplasmic network, and then discusses the propriety of associating with this organism the Coccoliths and Coccospheres, as Huxley has done. He does not arrive at definite conclusions on this point; but re-figures all the various forms of Coccoliths, Cyatholiths, and Discoliths described by Huxley. Haeckel would at present definitely establish Bathybius on the

protoplasmic network, and leave the exact origin of the Coccoliths doubtful. A very remarkable observation which he has made necessitates this; for he has discovered a new genus of oceanic Radiolarians, in the centre of each specimen of which he finds a mass of concretions which really cannot be distinguished from a Coccosphere. In fact, we may say that Coccospheres are found inside these new Radiolarians. At present there is nothing to show how they got there: whether they are secretions of the Radiolarian, or whether they have been taken in by it. Meanwhile the Coccoliths have been observed in other oceanic accumulations besides the Atlantic mud and the Chalk.

Miscellaneous.

Mr. Darwin and the French Academy.—At the outbreak of the present war between Germany and France, the claims of our great naturalist, to be elected a corresponding member of the French Academy, were under discussion in that body. There is nothing which has so fully illustrated the difference between the scientific attitude of France—or rather let us say Imperial France—and Germany, as the manner in which the views of Mr. Darwin have been treated in these two countries. In Germany their almost universal adoption has been the signal for the most active and valuable investigations "fur Darwin;" and the brilliant researches of Fritz Müller, Haeckel, Kowalewsky, and others have proceeded directly from this as a cause. Imperial France on the other hand has, with a rare exception here and there, treated Mr. Darwin with scorn and even insult. M. Flourens, the late perpetual secretary of the French Academy, made a most unseemly attack upon Mr. Darwin some years since, which Professor Huxley showed up for the amusement of English readers in an article in the 'Natural History Review,' which is reprinted in his volume of 'Lay Sermons.' In the recent discussion on Mr. Darwin's claims, MM. Milne-Edwards and De Quatrefages did justice to his merits as an observer, though they do not accept evolution; but Brongniart, Robin, and Emile Blanchard, appear to have expressed a very low opinion of him: he was called 'amateur,' an 'inaccurate dreamer;' and Eli de Beaumont, whose theory of mountain chains has been so completely crushed by Lyell, said that Darwinism "is all fizz"—"*c'est la science moussée.*" And yet it is a fact that Cuvier and Lamarck were Frenchmen.

A New Manual of Zoology.—Dr. H. Alleyne Nicholson, of Edinburgh, lecturer on zoology in one of the medical schools, has, with excellent intentions, produced a manual of zoology. He has not done rightly, for the book is almost entirely an abridgment of Huxley's lectures published in 1856 in the 'Medical Times and

Gazette,' of Greene's 'Manuals of the Cœlenterata and Protozoa' published eleven years since, and of Woodward's 'Mollusca' published fourteen years since. The only additions appear to relate to the geological range of the various groups of animals. No attempt is made to give any of the later results of investigation, nor to seek information from original memoirs. The writer gives his statements at third-hand, and with the exception of some rough diagrams, his figures have appeared in many a manual of zoology published during the last twenty years.

Chloral, the New Opiate.—It is little more than a year since Liebreich suggested the use of the hydrate of chloral as an anodyne, and a few grains of it were obtained at the Exeter meeting of the British Association, through the Pharmaceutical Association, for experiment. Within six months of that time, such is the rapidity with which the medical profession avails itself of any new and valuable discovery, chloral was in daily use in nearly every London and provincial hospital. However much we may complain of backwardness in England in some scientific matters, we cannot but express admiration at the remarkable activity of our medical men. It has been urged upon the bodies who are sending relief to the wounded soldiers in France, to forward chloral and chloroform. Any individual who should go the round of the hospitals, or even on the battle-fields themselves, and administer chloral to those suffering from the pain of wounds, would be able to spare an immense amount of agony, and save many lives. This is one of the adjuncts of war which science offers as a set off to her *mitrailleurs*. Chloral has also lately been used with much success in some cases by Dr. Robert Caton, in making various physiological experiments in place of curare or chloroform. His methods of studying the tissues of living animals under the microscope, are published by him in the last number of the 'Quarterly Journal of Microscopical Science.' We hear also that Dr. Sanderson, F.R.S., and Professor Stricker, of Vienna, who is now on a visit to this country, have succeeded by the use of chloral, and by proper precautions for maintaining temperature, in studying the living circulation of small mammalia, so as to extend to the mammalia the inquiries commenced by Waller, lately renewed by Cohnheim, as to the emigration of blood-corpuscles from the blood-vessels in inflammation. This is most important as bearing on human pathology and physiology, for hitherto such observations had been confined to the cold-blooded vertebrata—almost entirely, in fact, to fish and frogs, or toads.

Morphology.

Homogeny and Homoplasy.—In the July number of the 'Annals,' Mr. Ray Lankester proposes to use these terms to signify certain relations of parts in organisms which have hitherto been confused under the one head of homology. Homogeny is applied to such structures as owe their identity in arrangement and relation to inheritance from a common ancestor; parts which are thus rendered similar in two organisms are said to be homogenous one with the other. Many structures present, however, a very close similarity in their relations to surrounding parts in two organisms without being so inherited; the similarity being due merely to a community of external conditions in the two cases, necessitating similar corresponding internal arrangements. These agreements are said to be due to "homoplasy," and are called homoplastic one with another. The fore-limbs of all vertebrata are thus broadly homogenous, that is, are inherited from a common ancestor. But the four cavities of the heart of the mammal and of the bird are not homogenous each with each. The hearts as a whole are so, but since the common ancestor of birds and mammals had in all probability a heart with three cavities, the four cavities cannot be due to inheritance in the two cases. They are homoplasts; they are due to similar exigencies in the mammalian and ornithosaurian stock after their divergence from a common stock. Various instances of homogenetic and homoplastic agreement are distinguished in Mr. Lankester's paper, and it is pointed out that what are called serial homologies belong to the category of homoplasts; thus, the fore and hind limb of vertebrata agree in many of their details of structure on account of the mechanical arrangements required in fore and hind limb being to a very great extent identical. In a subsequent number of the same periodical, Mr. St. George Mivart, F.R.S., writing on the use of the term homology, accepts the terms homogeny and homoplasy, though he would retain Professor Owen's word homology, in a wide sense, distinguishing homogenetic homologies and homoplastic homologies. He also proposes to distinguish "ancestral homogeny" and "developmental homogeny." But it appears that "ancestral homogeny" is all that the term homogeny was defined to include. What Mr. Mivart calls "developmental homogeny," when it is not accompanied by ancestral homogeny, falls simply under the category of homoplasy. The subject is a little abstruse, but is of importance, since the doctrine of homology as propounded by Professor Owen has sunk very deeply into the mind of British anatomists; and now that so many have accepted the doctrine of evolution, and the doctrine of creation by types is no longer in favour, it becomes necessary to remodel our terminology in accordance with new ideas.

Quarterly List of Publications received for Review.

1. The Origin of Civilization and the Primitive Condition of Man. Mental and Social Condition of Savages. By Sir John Lubbock, M.P., F.R.S. *Longmans, Green, & Co.*
2. On Microscopical Manipulation. Being the Subject-matter of a Course of Lectures delivered before the Quekett Microscopical Club. *With 49 Engravings and 7 Lithographs.* By W. T. Suffolk, F.R.M.S. *Henry Gillman.*
3. Heat as a Mode of Motion. By John Tyndall, F.R.S. Fourth Edition. *Longmans, Green, & Co.*
4. Class-Book of Inorganic Chemistry. By D. Morris, B.A. *Phillip & Son.*
5. Chemical History of the Six Days of Creation. *New York: The American News Company.*
6. Papers on the Theory and Practice of Coal-mining. By George Fowler, Mining Engineer. *Wm. Hutchings.*
7. Notes of a Course of Seven Lectures on Electrical Phenomena and Theories, delivered at the Royal Institution of Great Britain. By John Tyndall, LL.D., F.R.S. *Longmans, Green, & Co.*
8. Annual Report of the Smithsonian Institution. *Washington: Government Printing Office.*

PAMPHLETS AND PERIODICALS.

Mineral Statistics of Victoria. *Melbourne.*

Smithsonian Contributions to Knowledge:—

The Transatlantic Longitude as Determined by the Coast Survey Expedition of 1866. By B. A. Gould.

The Indians of Cape Flattery. By James G. Swan.

The Gleddon Mummy Case. By Charles Pickering, M.D.

The Orbit and Phenomena of a Meteoric Fire-ball. By James H. Coffin, LL.D. *Washington: Smithsonian Institution.*

Index to his Observations on the Genus Unio. By Isaac Lea, LL.D. *Philadelphia: T. K. Collins.*

On the Size of Red Corpuscles of the Blood of Moschus, &c. By G. Gulliver, F.R.S.

First Report of the River Pollution Commissioners. (Blue Book.)

Narrative of a Journey to Musardu. By Benjamin Anderson.
New York: S. W. Green.

Remarks on Prof. Owen's Monograph on Dimorphedon. By Harry G. Seeley, F.G.S. *Taylor & Francis.*

On the Artificial Formation of Organic Compounds. By J. Campbell Brown, D.Sc. Lond.

On Ailanthus Excelsa; a new Indian Remedy. By Mr. Narayan Daji. *Bombay: Asiatic Press.*

A System of Botanical Analysis applied to the Diagnosis of Natural Orders. By W. H. Griffiths, Ph.D. *Wyman & Sons.*

A Sketch of a Philosophy. Part III.: The Chemistry of Natural Substances. By John G. Macvicar, LL.D., D.D.
Williams & Norgate.

A Lecture on Malt Liquor. By Joseph Livesey.

Public School Reforms. By M. A. B.

Biology *versus* Theology. By Julian.

Statement of a recently-claimed Discovery in Natural Science. By Research. *Melbourne.*

Railway across the Himalaya, projected by R. Stirling, Esq., F.R.S.

Contributions to the Mineralogy of Victoria. By George H. F. Ulrich, F.G.S. *Melbourne: John Ferres.*

Report of the Examiner of Coal-fields in New South Wales. In the 'Newcastle Pilot' (Australia).

Metropolitan Board of Works. Report on Steam Road-Rolling. By F. A. Paget, C.E.

Notes on Books. *Longmans.*

On the Cause of the Motion of Glaciers. By James Croll.

On the Scientific Use of the Imagination. By John Tyndall, LL.D., F.R.S. *Longmans.*

The Technologist. *New York: The Industrial Publication Company.*

The Canadian Naturalist. *Montreal: Dawson Brothers.*

The Food Journal. *London: Johnson, 3, Castle Court, Holborn.*

The American Naturalist. *Salem: Peabody Academy of Science.*

The Geological Magazine. *Trübner & Co.*

Scientific Opinion.

The American Chemist. *New York: Baldwin & Co.*

The English Mechanic.

The Westminster Review.

Revue Bibliographique Universelle.

Fraser's Magazine.

The Popular Science Review.

PROCEEDINGS OF LEARNED SOCIETIES, &c.

Vargasia. Boletin de la Sociedad de Ciencias fisicas y Naturales de Caracas. *Caracas: Imprenta del Estado Bolivar.*

Öfversigt af Kongl. Vetenskaps-Akademiens Förhandlinger. *Stockholm: Norstedt & Sons.*

Proceedings of the Lyceum of Natural History in the City of New York.

The Journal of the Historical and Archæological Association of Ireland.

Transactions of the Woolhope Naturalists' Field Club.

Fifth Report of the Quekett Microscopical Club.

Proceedings of the Royal Society.

„ „ Royal Institution of Great Britain.

Monthly Notices of the Royal Astronomical Society.

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